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IMPACT OF REMOTE SENSING UPON THE PLANNING, MANAGEMENT, AND DEVELOPMENT OF WATER RESOURCES

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15. Supplementary Notes introduction of new data streams by contrasting the current trends of water resource users, both with and without remote sensing data.

16. Abstract A survey of the principal water resource users was conducted to determine the impact of new remote data streams on hydrologic computer models. The analysis of the responses and direct contact demonstrated that:

1. The majority of water resource effort of the type suitable to remote sensing inputs is conducted by eleven major federal water resources agencies or through federally stimulated research.

2. The federal government develops most of the hydrologic models used in this effort.

3. Federal computer power is extensive.

The computers, computer power & hydrologic models in current use were determined.

The effort in the remainder of the contract will be directed toward analyzing the effect of feasibility & timing of (SEE SUPPLEMENTARY NOTES)

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Figure 2. Technical Report Standard Title Page

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1.0 PREFACE

In the short time since ERTS has been launched, many interesting and provocative results of immediate and future benefit to water resource users have been identified. The impact of remote sensing data on water resource problems is potentially large and will be realized as continuous streams.

Hydrologists and water resource planners are presented with the opportunity of repeatedly observing at the sub-macro level surficial and surface-inferred subsurface parameters which, when incorporated into the technology, could significantly contribute to man's understanding and proper use of his water resources.

Remote sensing technology is rapidly approaching a phase of maturation, wherein several important, specific applications can be translated into operational user procedures. Principal among these are:

1. Determination of runoff from ungaged and gaged watersheds;
2. Delineation of the extent of flood plains;
3. Improved assessment of irrigation water demand;
4. More precise determination of the runoff from snowmelt.

There are, however, two major problems implicit in the rapid and cost-effective adaptation of these new remotely sensed data streams into current water resource practices. The first is the theoretical development of relationships having hydrologic importance and which are sensitive to remotely sensed parameters, i.e. relating surficial characteristics to required hydrologic variables. The second is the identification and alleviation of bottlenecks which may be caused by the large mass of data which can and already is being made available from ERTS.

An ancillary requirement is the updating of existing hydrological models to accept new and/or improved remote sensing dependent data streams, and the construction of new models specifically tailored to and structured around remotely sensed data.

2.0 TECHNICAL DISCUSSION

The purpose of this effort is to: 1) identify and quantify the data load dependent computer problems resulting from remote sensing data inputs into current and future hydrologic models and data gathering; 2) assess remote sensing data impacts; and 3) develop guidelines for alleviating these problems to permit the most rapid and cost-beneficial application of remote sensing technology to water resource problems. The present first quarterly report describes the effort to date; specifically:

1. Identifying the water resource users requirements, practices to provide a data base to assess remote sensing data impacts;
2. Relating these user requirements to remote sensing technology;
3. Identifying and analyzing the hydrologic computer models and computer characteristics in present use by the principal water resources users; and
4. Identifying the residual contract effort necessary to specify means of overcoming the impediments described above.

2.1 SURVEY OF PRINCIPAL WATER RESOURCE USERS

The first task undertaken was to analyze the principal agencies, universities and private organizations active in the water resources field. This was accomplished by extensive in-house literature research and by directly contacting water resources "users" in the following sectors:

1. Federal;
2. State;

3. City and County;
4. Universities;
5. Private contractors

An inventory of the specific organizations surveyed is included in Appendix A.

Table 1 summarizes the responses received and indicates the extent of the coverage obtained. In all, a total of 75 individual agencies provided information and data. These organizations process 224 different hydrologic models on 172 computers, with a wide variety of water resources uses. While it is clear that water research activity is substantial at all levels, further examination shows that commitment to water resource projects of the type which could directly benefit from remote sensing inputs is centered mainly in direct federal or federally funded activities.

Each of the states have one or more agencies which deal with water resource problems. The activities of these groups are contained in Appendices B through D which list the water resource activity by type, models used and computer complement. State agencies operate 28% (by number) of the computers found in our sample, and 47% of the hydrologic models identified by the sample. This level of activity, although significant, requires further qualification. First, the range of function of state organizations

TABLE I

SUMMARY OF RESPONSES TO WATER RESOURCES SURVEY

	Agencies Surveyed	Agencies Responding	Number of Computers Used	Number of Different Models Used	No. of original Models with Remote Sensing Potential
Federal Agencies	11	11	75	47	37
State Agencies	50	31	49	106	30
State Water Resource Inst.	50	12	24	37	18
Universities	67	12	14	22	6
Local Governments	3	3	1	1	1
Private Contractors	6	6	9	11	0
TOTALS	187	75	172	224	92

varies greatly with the wealth of the state and the magnitude of its water resource problems. California and Texas alone, for example, operate 36% of the models used by all the states and 27% of the computers. Second, analysis of the models used by the states shows that they are generally adapted from models created by federal agencies or through federal agency support. A significant amount of the computer models in use by the states especially address those elements of hydrology in which remote sensing data has little or no direct impact, e.g. backwater curves requiring detailed channel cross section information, statistical support programs, stage discharge computational programs, etc. Table 1 also shows that less than 30% of total models used by the states were originated in that sector and are of the type suitable to remote sensing input. Third, the water resources research budgets of state agencies are typically orders of magnitude less than the budgets of the federal departments involved in similar research.

State Water Resource Research Institutes were also surveyed. The activities of these centers, shown in Appendix E, actually represent an extension of federal involvement in water resources since they are funded as a result of the 1964 Water Resource Research Act. As can be seen in Appendix F, most of the models used by the Water Resources Research Institutes have their source in the federal government. The use of large computers by these agencies is small and the percentage of this use devoted to water resources is, in all but one case where figures are given, 5% or less (see Appendix G).

The response of the local water resource agencies contacted was combined with budget information from the large counties and metropolitan governments, permitting the following conclusions:

1. County and local budgets for the hydrologic aspects of water resources are small by comparison to the federal government.

2. The greatest share of local government appropriations for water are channeled into the construction of civil works, an area which would indirectly benefit from remotely sensed data as improved design inputs; but are not immediately impacted by new data remote sensing data streams.

Universities do operate significantly in the field of basic hydrologic research and, therefore, are producers of original water resource models. Their work, however, is again mainly dependent upon federal stimulation. Figure 1 shows the magnitude of research support from the federal agencies, of which a significant percentage is given to universities. For example, the Office of Water Resources Research gives 87% of its allocation of $12,400,000 to universities and other non-profit organizations. Likewise, the Bureau of Reclamation gives 69% of its allocation of $5,119,000 to universities. The university sector may be

FIGURE I

FEDERAL SUPPORT OF WATER RESOURCES RESEARCH

FY 73

Dept.	Agency	Funding Budget in 1973 Dollars
DOI	USGS	$550,000
	BUREAU OF RECLAMATION	5,119,000
	FISH AND WILDLIFE SERVICE	381,000
	BPA	---
	OWRR	12,400,000
DOA	FOREST SERVICE	---
	ARS	---
	SCS	2,472,000
DOC	NOAA	986,000
DOD	COE	4,315,000
EPA		15,957,000
TVA		5,000

viewed as an extension of federal involvement. The responses received from the universities are summarized in Appendix H.

There are similar findings regarding the private contractors. They also depend upon funds from the government typically, however, from the local sector. Furthermore, the orientation of those companies contacted was again toward public works design. Their responses are included as Appendix I.

Analysis of the total water resource effort of all sectors then gives rise to the following conclusions:

1. The federal government directly and through its university and state Water Resources Research Institute support programs is the principal developer of hydrologic models and generally is the sector wherein the models are first reduced to practice. Therefore, the sensitivity of water resources to remote sensing data input can most profitably and adequately be tested by analysis of this sector.

2. Water resource activity of other government sectors, private, state and university organizations of the type directly sensitive to remote sensing data input is primarily federally stimulated. The large bulk of the money and activities of these sectors is centered on construction and fiscal operation of civil works. Benefits induced by the impact of remote sensing on the federal sector will have an important but time delayed impact in these sectors. This will be factored into the final analysis to show magnitude of the benefits.

2.2 Principal Federal Water Resources Research Agencies

Of all federal agencies involved in water resources, the eleven listed below spend 93%, or approximately 470 million dollars, of the total federal water resources research budget of approximately 509 million dollars (FY 1973). The investigation has therefore concentrated on these departments, which follow:

1. Department of Commerce - National Oceanographic & Atmospheric Administration
2. Department of Agriculture
   a. Agricultural Research Service
   b. Soil Conservation Service
   c. Forest Service
3. Department of the Interior
   a. Geological Survey
   b. Bureau of Reclamation
   c. Fish and Wildlife Service
   d. Bonneville Power Administration
4. Environmental Protection Agency
5. Department of Defense - Army Corps of Engineers
6. Tennessee Valley Authority

A summary of the activities and detailed budget of each agency is given in Appendix J.

Figure 2 presents an agency-by-agency breakdown of water resources research and total budgets of the eleven agencies surveyed (for FY 1973).

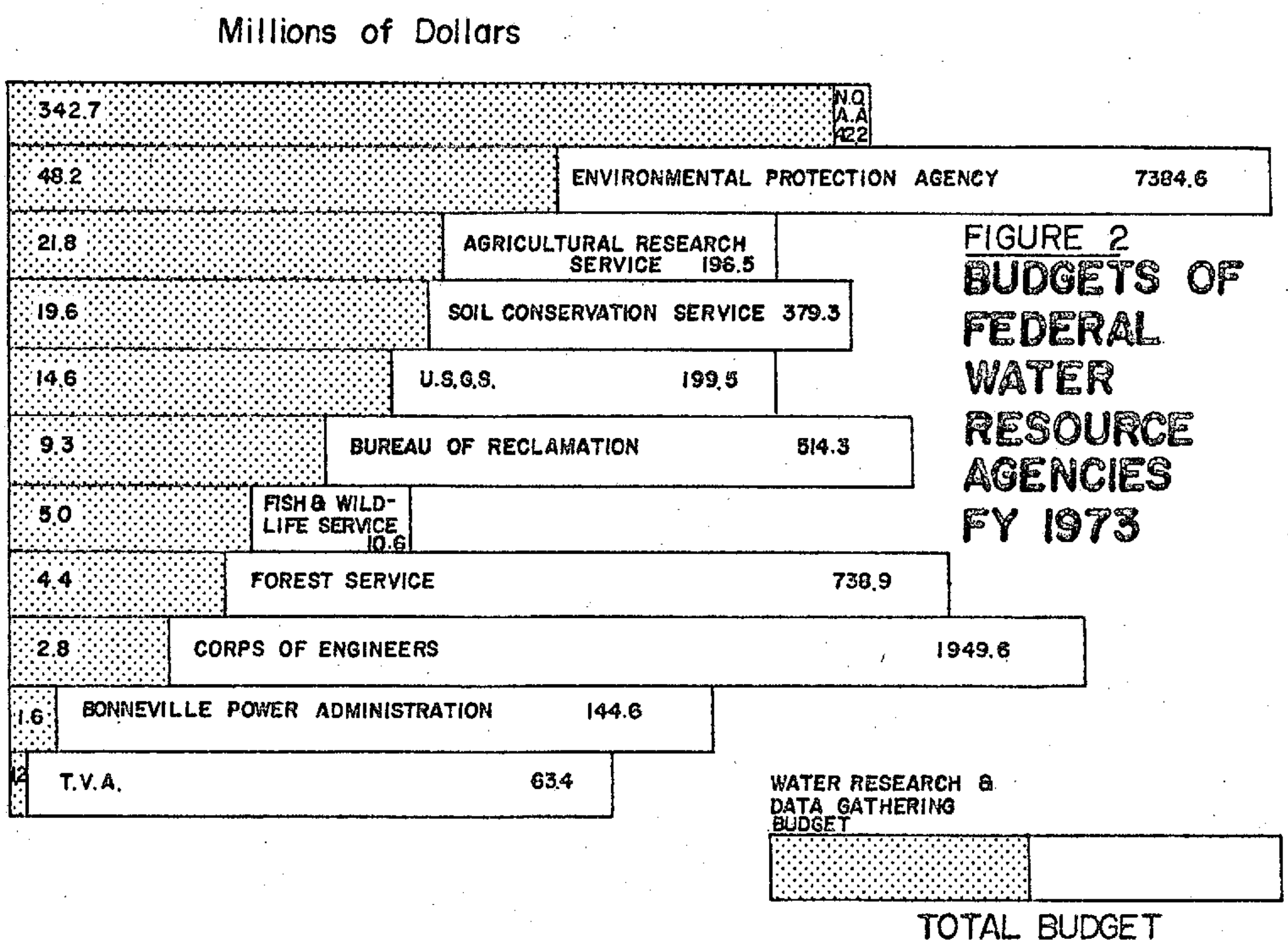

FIGURE 2
BUDGETS OF FEDERAL WATER RESOURCE AGENCIES FY 1973

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2.3 FOCUS OF PRINCIPAL FEDERAL AGENCIES RELATIVE TO REMOTE SENSING

In order to assess the potential impact of remote sensing technology on the planning, management, and development of water resources, it is important to determine whether the federal water agencies concentrate their efforts in activities potentially affected by input of remote sensing data.

An inventory which appears in Appendix J was taken of the primary functions of the eleven water resource agencies listed in the previous section. Of these activities, the following were determined to be not directly amenable to remote sensing:

1. Activities which are not intrinsically adaptable to remote sensing, such as subsurface flow studies;
2. Purely economic considerations, such as the marketing of surplus electric power;
3. Construction projects, such as the building of dams;
4. Legal activities, such as the determination of water rights.
5. Administrative functions.

The residual water resource activities that could not be definitely ruled out were considered to be potentially amenable to remote sensing and were grouped into sixteen areas, listed and briefly explained in Table 2.

TABLE 2

WATER RESOURCES AREAS AMENABLE TO REMOTELY SENSED DATA

Hydrologic Modeling	Study and modeling of basic physical hydrologic processes.
Urban Hydrology	Assessment of urban storm drainage and effects of urbanization upon runoff.
Flood Plain Mapping	Physical and cartographic delineation of land areas inundated by peak flows.
Influence of Land Use	The application of land management practices as they relate to stream, lake or estuarine resources.
Water Resources Inventory	Location and classification of water, and identification of areas of critical concern (ex., aquifer recharge areas, coastal zones, etc.).
Lake and Estuarine Hydrology	Basic hydrology of lakes and estuaries, including water movement, wave action, interlake flow, and limnology.
River Hydraulic Modeling	Study of tidal hydraulics, wave phenomena, and shore processes.
Flood Control	Reservoir sizing and non-construction alternatives of flood control.
Rainfall/Runoff Modeling	Streamflow determination, hydrograph analysis, and watershed transfer function development.
Reservoir & Water Supply Management	Operation of reservoirs and determination of supply and demand.
Meteorological and Hydrological Data Analysis	Compilation, synthesis and summarization of weather and water data.
Sedimentation & Erosion	Study of sedimentation, siltation, and erosion and development of methods of problem amelioration.
Flood Forecasting	Determination of peak flows and river stage forecasting.
Snowmelt/Yield	Snow surveys, snowmelt models, and relation of snowmelt to water supply and runoff.
Thermal Pollution	Study of effects of temperature alterations on water bodies.
Water Quality	Location, classification and abatement of pollution.

It is possible to determine how the eleven federal water resource agencies would be impacted by remote sensing technology by determining how and to what extent each agency is involved in the activities defined in Table 2. A consideration of Figure 3, which compares agencies with functions, leads to the following conclusions:

1. All of the federal water organizations surveyed are engaged in activities that are potentially amenable to remote sensing data.

2. The Corps of Engineers, NOAA, the Geological Survey, TVA, and SCS are the agencies that are involved in the largest variety of areas potentially amenable to remote sensing technology. Therefore, these agencies constitute the most likely set of Earth Resources Satellite data users.

3. Though the range of agency activities is fairly diverse, some concentration can be observed in rainfall/runoff modeling, reservoir/water supply management, meteorological/hydrological data and snowmelt yield. The introduction of remote sensing to water resources, then, would be facilitated by stressing applications in these areas.

4. Those agencies that perform the most diverse functions also concentrate their effort in areas with the largest common involvement.

AGENCY / FUNCTION	FLOOD PLAIN MAPPING	INFLUENCE OF LAND USE	WATER RES. INVENTORY	HYDROLOGIC MODELING	URBAN HYDROLOGY	LAKE/ESTUARY HYDROLOG	RIVER HYDRAULIC MODELIN	FLOOD CONTROL	RAINFALL-RUNOFF MODELING	RES./WATER SUPPLY MGN	METEOROLOGICAL/HYDRO. DATA ANALYSIS	SEDIMENTATION/EROSION	FLOOD FORECASTING	SNOWMELT/YIELD	THERMAL POLLUTION	WATER QUALITY	TOTAL
N.O.A.A.				░		░			░		■		░	░		░	7
AGRICULTURE RESEARCH SERVICE		■		░							░	░					4
SOIL CONSERVATION SERVICE		■						░	░	░		░		░			6
FOREST SERVICE		■										░		░			3
GEOLOGICAL SURVEY	░		░	░	░	░			░		■						7
BUREAU OF RECLAMATION								░		■	░						3
FISH & WILDLIFE SERV.						░									░	■	3
BONNEVILLE POWER AD										■				░			2
ENVIRONMENTAL PROTECTION AGENCY				░											░	■	3
CORPS OF ENGINEERS	░				░		░	░	░	■		░	░	░			9
TENNESSEE VALLEY AUTHORITY		░			░			░	░	■	░				░		7
TOTAL	2	4	1	4	3	3	1	4	5	5	5	4	2	5	3	3	54

FIGURE 3 FUNCTIONS OF FEDERAL AGENCIES POTENTIALLY AMENABLE TO REMOTELY SENSED DATA

Major Function ■ Other Functions ░

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2.4 RELATIONSHIP OF REMOTE SENSING DATA INPUTS TO THE PRINCIPAL HYDROLOGIC MODELS

The computer models used to describe hydrologic processes and events can be used as an indicator of the impact of new data inputs on water resources activity. Therefore, the potential capability of earth resources satellites to supply remotely sensed information must be analyzed in relation to the specific data requirements of the principal models in use.

A survey of models used by the federal water resource agencies, included as Appendix K, reveals two facts:

1. All of the organizations surveyed are active in modeling, with the exception of the Fish and Wildlife Service.

2. Most of the models utilized were developed in-house.

Table 3 lists and describes the inputs to hydrologic models which would potentially be impacted by remote sensing technology and describes the mechanism by which the data is used. In Figure 4, these inputs are related to specific models, singled out for analysis because they generally combine a representative set of water resource users with potentially high remote sensing impact. Two immediate conclusions can be drawn from Figure 4:

1. The remote sensing inputs having the most universal applicability to the models are: drainage area, used by 100% of the models considered; vegetative cover, used by 67% of the models; and temperature, used by 67% of the models.

TABLE 3

POTENTIAL REMOTE SENSING INPUTS TO HYDROLOGIC MODELS

Vegetative Cover	Cover is an indicator of potential evapotranspiration, interception, surface roughness, and permits some inference of subsurface characteristics.
Snow Cover	Areal extent or water content of snow is applied to calculation of yield
Land Use/Change	Land use and change can be input to allow for seasonal cover fluctuations or urbanization effects.
Drainage Area	The geographic dimensions of watersheds and subsurface terrain variations are indicative of magnitude of runoff mass and flow rate.
Drainage Density	Average distances of overland flow to streams are used to deduce the time distribution of runoff. Drainage density is applicable as an input parameter to rational formulas.
Surface Water	Surface water contributes to total impermeable area. Standing water comprises, in part, surface detention capacity.
Soil Association	Soil type is an inferential determinant of infiltration rate and moisture capacity.
Soil Moisture	Antecedent moisture in the surficial soil level sets residual water capacity and indicates the propensity of the soil to produce surface flow.
Impermeable Areas	The areal extent and distribution of surfaces which prohibit infiltration influence runoff mass and flow rate.
Cloud Cover	Cloud cover acts to limit temperature available for evapotranspiration.
Temperature	Temperature indices will determine the form of precipitation (rain or snow), and influence evapotranspiration rate.

MODELS \ VARIABLES	VEGETATIVE COVER	SNOW COVER	LAND USE/ LAND USE CHANGE	DRAINAGE AREA	DRAINAGE DENSITY	SURFACE WATER	SOIL ASSOCIATION	SOIL MOISTURE	IMPERMEABLE AREAS	CLOUD COVER	TEMPERATURE
USDAHL-70 74	X	X	X	X			X	X			X
USGS				X			X	X	X		X
UTAH STATE U.	X	X	X	X	X	X	X	X	X		
STANFORD MODEL	X	X		X	X	X	X				X
TEXAS MODEL	X	X		X	X	X	X	X			X
HYDRO 14	X			X	X	X	X	X	X	X	X
HYDRO 17		X	X	X						X	X
API	X		X	X							
SSARR		X	X	X		X		X			X
COSSARR		X	X	X		X		X			X
TR-20	X		X	X	X		X				
USGS REGRESSION EQUATIONS	X			X							

FIGURE 4 VARIABLES OF WATERSHED MODELS AMENABLE TO REMOTE SENSING

2. The models which are potentially impacted by the highest number of remote sensing inputs are: the Utah State University model, which uses 9 of 11 inputs; the Hydro 14 model, which uses 9 inputs; the Texas model, which uses 8 inputs; the Stanford Watershed model, which uses 7 inputs; and the USDAHL-70, 74 model, which uses 7 inputs.

Table 4 illustrates the technique by which the information shown in Figure 4 was developed and analyzes the role of each of the remote sensing inputs in the USDAHL - 70, 74 model. Seven areas where remote sensing data would be contributive are identified. The importance of vegetative cover, land use and change, and drainage area inputs, which can presently be assessed by remote sensing, to the USDAHL-70, 74 model is shown. Measurement of the distribution, seasonal and growth state of agricultural crops and the areal extent of the basin would be involved. Figure 5 shows the complete input/output analysis of the USDAHL - 70, 74, including important processes, remote sensing inputs, non-remote sensing inputs, physical and non-physical model parameters, outputs and principal uses. Similar information is available on the other principal models.

2.5 COMPUTER REQUIREMENTS OF THE PRINCIPAL MODELS AND AGGREGATE COMPUTER COMPLEMENT IN THE FEDERAL WATER RESOURCE USER COMMUNITY

Most of the models identified require large capacity digital computers. The impact of new remote sensing data streams can best be asssed relative to the existing computer requirements. Computer requirements, however, vary significantly

TABLE 4

DESCRIPTION OF POTENTIAL REMOTE SENSING INPUTS

USDA-HL-70, 74

Vegetative Cover	Model is for agricultural watersheds a crop growth index is input weekly for each crop growth = % of maturity of crop. The growth index is also used as a vegetative factor in Holtan infiltration equation.
Snow Cover	Water equivalent of snow mass used as precipitation input, but results are not good for HL-70.
Soil Moisture	Holtan infiltration equation requires specification of maximum soil moisture capacity.
Soil Association	Will determine infiltration rates. Also, the model divides the watershed into soil zones to compute ET and overland flow. Depth of soils is also input.
Land Use/Change	Crop cover is input - seasonal changes can be accounted for.
Temperature	Average daily evapotranspiration is input as a model parameter.
Drainage Area	Watershed area and area of soil zones are input. (Areal effects of rainfall are ignored)

Purpose				Where Used
FLOOD FREQ.		ECONOMIC		Agricultural Research Service U.P.I. Agricultural Experiment Station
HYDROGRAPH	X	FLOOD DAMAGE		
LOW FLOW FREQ.		RESERVOIR MGT.		
SNOWMELT				

(Model Parameters)

1. Three Soil Zones
2. Flow & Routing Nos.
3. Soil Depth, Porosity
4. Saturated Conducitivity
5. Surface Roughness
6. Area
7. Number of Crops
8. Avg. Daily ET
9. Initial Channel Flow
10. Calculation Time Interval

Data Inputs								Data Outputs					
Flow Data	Antecedent Moisture	Cover	Rainfall	Snowmelt	Temperature	Evapotranspiration	Crop Growth Index	Hydrograph	Discharge Peaks	Snowmelt	Economic Data	Reservoir Mgt. Requirements	
			x				x	x	x				

Parameter Adjustment Requirements	Length of Record Requirements
None	Maximum of 50 Days

Remote Sensing Potential											
Vegetative Cover	Snow Cover	Drainage Density/Pattern	Surface Water	Soil Moisture	Impermeable Areas	Soil Association	Thermal / Sediment Plumes	Cloud Cover	Land Use/Change	Temperature Contours	Drainage Area
x	x			x		x			x	x	x

FIGURE 5

from model to model, due to any of the following factors:

1. Length of the data streams.
2. Frequency of simulation time interval.
3. Number of nodes or flow points modeled.
4. Number of physical processes considered.
5. Adherence of simulation to actual physical hydrology.
6. Mathematical relations used to model hydrologic phenomena.

Specific examples of the computer requirements and characteristics of the models are given in Table 5. The most obvious difference is the amount of core storage required.

In order to assess the impact of new remote sensing data on water resource ~~users,~~ a calibration of the current computer capabilities of the users is required. Total 1974 federal water resources data processing capacity is approximately 30 million instructions per second. An analysis of the agencies making up the user community sample is found in Appendix L, leads to three conclusions. First, it is clear that:

1. Federal computer hardware devoted to water resources is substantial.
2. These computers typically are not devoted exclusively to water resources but are applied to other functions of the agencies as well.
3. All but one of the agencies considered depend completely upon their own computer resources and do not contract work.

The characteristics of the computers pertinent to the analysis

Table 5 COMPUTER CHARACTERISTICS OF HYDROLOGIC MODELS

MODEL NAME	BASIN SIZE	COMPUTER	ASSUMPTIONS	CORE STORAGE REQUIREMENTS	COMPUTER TIME USED
USDA HL-70-74	<100 mi.^{2}	IBM 360/30	For agricultural watersheds. Divide basin into uplands, hillsides & bottom land zones. One year simulation. Includes rain, temperature, soils, and crop data.	98K	19 sec.(compile) CPU
		IBM 360/65			1.5 min. compile time; 1 min. CPU/ year simulation
U.S.G.S. Rainfall-Run-off Model	<50 mi.^{2}	IBM 360/65	Uses 5 yr. records of rainfall, ET, and discharge. Stage determined from 10 parameters which are calibrated through 10 iterations per parameter.	420K	35 sec. (compile) CPU; 180 sec. - execution time.
Utah State U.	no limit	Analog = 10 pots. 4 multipliers, 5 integrators, 5 summers 8 inverters	Urban watershed modeled by an equivalent rural basin. Models precipitation, interception, infiltration, depression storage, routing.	n/a	1 sec. computer time=30 min. of simulation
Stanford Watershed Model (and modifications)		IBM 360/75	One year simulation from precipitation input. 16 parameters are calibrated through iterative process.	150K	35 sec. CPU
Hydro 14		CDC 6600	Models 14 days data including 10 snowpack or soil moisture accounting areas with 10 streamflow nodes, 5 upstream inflow points, 3 pe. stations	29K	10 sec. CPU

Ta[redacted] 5[redacted]COM[redacted]UTE[redacted] C[redacted]ARA[redacted]TERI[redacted]STIC[redacted] O[redacted]HY[redacted]ROL[redacted]GIC[redacted]MOD[redacted]S

MODEL NAME	BASIN SIZE	COMPUTER	ASSUMP ONS	CORE STORAGE REQUIREMENTS	COMPUTER TIME USED
SSARR		IBM 360/50	Thirty and sixty day, daily simulation of flows on a 100 node basin.	150K	480 sec. execution time (30 days)
COSSARR	>11 mi.^{2} usually very large basins	IBM 1130		80K	900 secs. execution (60 days)
SCS-TR20		IBM 360-370		210K	1080-1200 secs. run time
U.S.A. Corps of Engineers					
HEC-1		Large Dig.		32K	
HEC-2		Large Dig.		60K	
HEC-3		Medium to Large Dig.		60K	
HEC-4		Medium to Large Dig.		60K	
HEC-5		Medium to Large Dig.		60K	
Chicago (N.E.R.O.)	small urban watersheds	IBM 1130	25 Drainage areas modeled	8K	600 secs.
			1000 Drainage areas modeled		7200 secs. -include print-out time
MIT		IBM 360/65	Uses probability distributions of distribution, depth, duration and time between storms.	380K	10 sec. CPU 1500 sec.-(1 yr. execution time)

of remote sensing data impact are given in Table 6 . Generally, federal computers are of medium or greater speed and capacity. It is clear that this array of computer hardware represents a vast potential resource which could be tapped in the introduction of remote sensing data to hydrologic modeling.

Subsequent analysis, in the next phase of the contract will explicitly determine the critical data load impacts related to significant remote sensing inputs. However, the observed large unused capacity of the computers tends to indicate that critical impact will be in two areas:

1. In increased capability and hardware required to preprocess the satellite remote sensing radiometric data;

2. Development and proof of techniques for translating remote sensed data into usable hydrologic parameters.

TABLE 6

PROCESSOR SPEED CAPACITY

COMPUTER	1	2	3	4	5	6	No. Used
CDC 7600	.275	—	—	.0275	—	65	3
CDC 70174	1.0	60	.3	—	—	32-131	2
CDC 6600	1.0	—	—	.3	—	32-131	3
CDC 6400	1.0	—	—	1.1	—	32-131	1
CDC 3100	1.75	24	3.5	—	—	8-32	1
CDC 1700	1.1	16	2.2	—	—	4-32	2
GE 4020	1.6	24	3.2	—	—	8-32	1
GE 225	18	—	—	36	—	4-16	12
HONEYWELL 635	1.0	72	1.9	—	—	65-262	1
HONEYWELL 6437	—	—	—	—	—	—	1
IBM 370/168	.16	32	—	—	5	1000-8000	2
IBM 370/165	.16	64	.15	1.42	5	524-3145	1
IBM 360/91	.75	—	—	.18	—	512-1024	2
IBM 360/75	.75	64	.8	4.8	5	262-1048	2
IBM 360/65	.75	64	1.3	5.2	5	262-1048	2
IBM 360/50	2	32	4	20	5	131-524	4
IBM 360/40	2.5	16	12	40	5	32-262	1
IBM 360/30	1.5	8	30	57	5	16-65	2
IBM 360/20	3.6	8	58	160	5	4-32	1
IBM 1800	2.0	16	4.5	—	—	4-32	1
IBM 1620	2.0	—	—	560	—	20-60	1
IBM 1401	11.5	—	—	402	—	4-16	1
IBM 1130	2.2	16	4.8	—	—	4-32	21
DEC-PDP 12	1.6	1.2	3	—	—	4-32	1
XEROX SIGMA 7	.85	32	1.7	—	—	8-131	1
UNIVAC 1108	.75	36	.75	—	—	65-262	4

1. Storage Cycle Time (μ sec)
2. Storage Block length (bits)
3. Binary Add Time (μ sec)
4. Decimal Add Time (μ sec)
5. Decimal Add Size (digits)
6. Thousands of Addressable Units

CHARACTERISTICS OF COMPUTERS USED IN WATER RESOURCE BY MAJOR FEDERAL AGENCIES

3.0 CONCLUSIONS

Preliminary results achieved and conclusions reached during this reporting period are as follows:

1. The great majority of water resources effort of the type suitable to remote sensing inputs is conducted as a result of direct federal commitment or through federally stimulated research.

   a. State government is active in water resources but typically builds upon basic work performed at the federal level.

   b. Local government and private industry operate also in water resources areas, but they are primarily concerned with the design and construction of civil works.

2. The federal effort is concentrated in eleven major water resource agencies, whose budgets are significantly larger than those of their counterparts at the state level.

3. The activities of the federal water resource research organizations are of the type which are potentially conducive to augmentation from remotely sensed information.

   a. Most basic research in hydrologic phenomena takes place in the federal government or through federal support of institutional research.

   b. Further, this research involves much computer modeling, and more specifically, modeling which has high remote sensing potential.

   c. It may be concluded, therefore, that development of new models based on remote sensing inputs or the adaption of existing ones to assimilate satellite data will occur within the federal government.

4. The federal computer hardware reservoir is extensive. However, to fully assess the impact of remotely sensed information upon it, careful analysis must be made of preprocessing hardware available to quickly handle the many routine computations inherent in the processing of satellite radiometric data.

5. The optimal introduction of remotely sensed inputs to water resources activities can be assessed by analyzing federal users and by concentrating on identifying and overcoming bottlenecks which may exist in that sector.

6. Two distinct avenues of impact must be carefully analyzed:

   a. The effect of new data streams upon existing large parametric computer models.

   b. Alterations and evolution of non-parametric models, which at present have small to medium computer requirements, as a result of new data inputs generated from remote sensing activities.

4.0 PROGRAM FOR THE REMAINDER OF THE EFFORT

Work for the remainder of the effort will be in the following areas:

1. The extent of use of hydrologic models in the U.S. will be ascertained so that they might be ranked according to magnitude of user benefits.

2. The models will further be rated on the basis of their need for and use of remote sensing data. This will permit the identification of those models which will yield the broadest benefits for a given level of remote sensing input.

3. Further trends in water resources activity and in computer usage will be charted considering both the presence or absence of remotely sensed information.

4. The feasibility and timing of availibility of new hydrologic inputs will be projected onto the current trend of water resource users.

5. The optimal mechanism for introduction of remote sensing data to water resources users will be identified. The following questions will be addressed:

    a. Can increased remote sensing information inputs be practically and beneficially absorbed by present water resource agencies/facilities?

    b. What is the changing character of the water resources as affected by remote sensing and what potential benefits accrue to the use of remote sensing data?

    c. What adaptation to technology, staffing, DP, or structures of current water resource users is necessary to optimally accomodate remote sensing inputs?

    d. What is NASA's technical hydrology/water resources and data formatting/handling/dissemination role to optimally accomodate item c?

    e. What changes/alterations, if any, are required in NASA's flight, ground truth, sensors to maximize benefits in water resources remote sensing?

5.0 APPENDICES

APPENDIX A

ORGANIZATIONS SURVEYED

Appendix A lists those water resource agencies from the federal, state, Water Resources Research Institute, university, local and private sectors which provided information on their water resource activities and computers and models used.

APPENDIX A

Organizations Surveyed

I. Federal Agencies

A. USDA

1. Agricultural Research Service
2. Soil Conservation Service
3. Forest Service

B. U.S. Army Corps of Engineers

C. U.S. Department of Commerce - NOAA

D. U.S. Department of the Interior

1. Geologic Survey
2. Bureau of Reclamation
3. Fish and Wildlife Service
4. Bonneville Power Administration

E. Tennessee Valley Authority

F. Environmental Protection Agency

II. State Agencies

A. Alabama Development Office, State Planning Division

B. Arkansas Dept. of Commerce, Division of Soil & Water Resources

C. California Dept. of Water Resources

D. Delaware Dept. of Natural Resources

E. Florida Dept. of Natural Resources

F. Idaho Dept. of Water Resources

G. Illinois

1. Dept. of Transportation, Division of Waterways
2. Illinois State Water Survey

H. Kansas Water Resources Board

II. State Agencies -- Continued

I. Kentucky Dept. of Natural Resources & Environmental Protection, Division of Water Resources

J. Maryland

1. Dept. of Natural Resources
2. Water Resources Administration

K. Massachusetts

1. Water Resources Commission, Division of Water Resources
2. Division of Water Pollution Control

L. Mississippi Board of Water Commissioners

M. Montana Dept. of Natural Resources and Conservation

N. Nebraska Natural Resources Commission

O. New Hampshire Office of Comprehensive Planning

P. North Dakota State Water Commission

Q. Ohio Dept. of Natural Resources

R. Pennsylvania Dept. of Environmental Resources

S. Puerto Rico Aqueduct and Sewer Authority

T. South Dakota Dept. of Natural Resources Development

U. Tennessee State Planning Office

V. Texas Water Development Board

W. Vermont State Water Resources Board

X. Virginia

1. Dept. of Conservation and Economic Development
2. State Water Control Board, Bureau of Water Control Management

Y. Washington State Dept. of Ecology

Z. Wisconsin Dept. of Natural Resources

Aa. Wyoming State Engineer's Office, State Water Planning Program

III. State Water Resources Institutes

A. University of California Water Resources Center

B. Colorado State University Dept. of Earth Resources

C. University of Hawaii Water Resources Research Center

D. Idaho Water Resources Research Institute

E. Purdue University Water Resources Research Center, Indiana

F. Louisiana Water Resources Research Institute

G. University of Maine at Orono Environmental Studies Center

H. Montana University Joint Water Resources Research Center

I. University of Nebraska-Lincoln Water Resources Research Institute

J. University of Puerto Rico Water Resources Research Institute

K. Clemson University Water Resources Research Institute, S.C.

L. University of Tennessee Water Resources Research Center

IV. Universities

A. University of Kansas

B. University of Kentucky

C. University of Nebraska

D. North Carolina State University (2 responses)

E. Ohio State University (2 responses)

F. Purdue University

G. University of Texas at Austin

H. Utah State University

I. Virginia Polytechnic Institute and State University

J. Michigan State University

V. Counties

A. Anne Arundel County, Maryland

B. Baltimore County, Maryland

C. Fairfax County, Virginia

VI. Private Consultants

A. Wilson T. Ballard, Baltimore, Md.

B. Dalton - Dalton - Little - Newport, Baltimore, Md.

C. Hittman, Columbia, Md.

D. Maty, Childs, and Associates, Baltimore, Md.

E. Rummel, Klepper, and Kahl, Baltimore, Md.

F. Whitman, Requardt and Associates, Baltimore, Md.

APPENDIX B

WATER RESOURCE ACTIVITIES OF STATE AGENCIES

Appendix B summarizes the activities of state water resource agencies by percentage of time devoted to different areas of research.

ORIGINAL PAGE IS OF POOR QUALITY

WATER RESOURCE ACTIVITIES OF STATE AGENCIES

STATE	AGENCY / ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGMT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Ala.	Development Office State Planning Div															
Ark.	Dept. of Commerce Div. of Soil and Water Resources			40			15	30				15				
Calif.	Dept. of Water Resources	3	29	20	3	5	13	0.3	2						22	2.7
	State Water Project		43	50			7									
Del.	Dept. of Natural Resources			20	50	30										
Fla.	Dept. of Natural Resources			X			(1)				X					
Idaho	% of Professional Staff Time Dept. of Water Resources			10		5	5					2	X	30	15	(2)
Ill.	Dept. of Transportation, Div. of Waterway	2	30	3			1	2			10	12				

(1) Most work done in this area.
(2) Administration, Dam Safety

X = Mentioned, but no percentage figure given.

STATE	AGENCY / ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGNT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
	State Water Survey			2	5	30	15	5		5	10	5				
Kan.	Water Resources Board			10		<5		<5							15	(3)
Ken.	Dept. of Nat. Res. & Environ. Protec. Div. of Water Res.		10	10			10				5					
Md.	Water Resources Administration			30			10	30			30					
Mass.	Water Res. Comm. Div. of Water Resources			X			(4)	X	X	X	X	X				
	Div. of Water Pollution Control				50	50										
Miss.	Board of Water Commissioners			10			40			25		10		15		
Mont.	Dept. of Natural Res. & Conservation		2	2		1	20	3	(5)	2	4	4				(6)

(3) Aquifer Simulation <5
Watershed Simulation <5
(4) Most work done in this area.
(5) Part of Rainfall-Runoff Computation & Modeling.
(6) Other Department Activities 62%

STATE	AGENCY / ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGNT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Neb.	Natural Resources Commission					5	10	5			5					
N.H.	Office of Comprehensive Planning			25		25				25		25				(7)
N.D.	State Water Comm.		20	15	1	3	10	4	2	5	10	5	15			(8)
Ohio	Dept. of Natural Resources						20				80					
Pa.	Dept. of Environ. Res., Bureau of Res. Programming	3	26	3	13	32	7	1		3		1			11	
Puerto Rico	Aqueduct & Sewer Authority			30	25	10	15	5		5		10				
S.D.	Dept. of Natural Resource Dev.		10	5		5	25			10	10	20				(9)
Tex.	Water Development Board	2		3		3	12	3			3	3	3			(10)

(7) Total time in water resources = 5.15%
(8) Construction 10%
(9) Land Use Inventory 10%
Other Resources Inventory 10%
(10) Estuarine Hydrology 3%
Estuarine Water Quality 3%

STATE	AGENCY	ACTIVITIES CONDUCTED (% of time for Res.) FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGNT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Vt.	Water Resources Board					10	90									
Va.	State Water Control Board, Bureau of Water Control Man.	5				30				5	30	2	12			
Wash.	State Department of Ecology		5	30	5	40	5						15			
W. Va.	Water Resources				10	25	35	10			10	10				
Wisc.	Dept. of Natural Resources	1		3	17	71		2			6					(11)
Wyo.	State Engineer's Office			25						25		25		25		

(11) Public Water Quality Monitoring 1%

APPENDIX C

HYDROLOGIC MODELS USED BY STATE AGENCIES

Appendix C lists hydrologic models used by the state water resource agencies. Applications and origins of the models are also included.

HYDROLOGIC MODELS USED BY STATE AGENCIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Arkansas	Dept. of Commerce Div. of Soil & Water Resources	Stanford Watershed Model - Ohio State Version	Rainfall-Runoff Computation & Mod.		Ohio State University
California	Dept. of Water Res.	Streamflow Simulation & Snowmelt for all Major Rivers & Streams in Calif.	Rainfall-R/O Computation & Mod. Snowmelt River Hydraulics	X	
		Estimate of Monthly R/O by % Deviation	Rainfall-R/O Com. & Mod.	X	
		Streamflow Rating Table	Data Gathering & Correlation River Hydrau.	X	
		Rain Frequency Analysis	Data Gathering & Corr. Rainfall-R/O Com. & Mod.	X	
		Unit Hydrograph	Rainfall-R/O Com. & Mod.	X	
		Reservoir Area Capacity Table	Reservoir-Water Supply Management	X	
		Backwater Curve for a Lined Channel	River Hydrau.	X	
		Hydrology Evaluation & Analysis Program	Data Ga./Corr.	X	
		Calif. Aqueduct Hydraulic Simulation Model	Public Works Design	X	
		Daily Water Flow Data Summary	Data Ga./Corr.	X	

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
California	Dept. of Water Res. (Cont.)	Daily Flow Data History File Update	Data Ga./Corr.	X	
		River Cross Section Plot	River Hydrau.	X	
		Water Level Plots	Data Ga./Corr.	X	
		Operation of the Calif. Aqua-duct Monthly Operation Sub-System 2 & 3 (2 models)	Public Works	X	
		Flood Flow Frequency Analysis	Flood Fore-casting	X	
		Probable Maximum Precipita-tion	Data Ga./Corr. Rainfall-R/O Com. & Mod.	X	
		Flood Hydrograph Package (HEC-1)	Rainfall-R/O Com. & Mod.		U.S. Army Corps of Engineers
		Unit Graph & Hydrograph Computation	Rainfall-R/O Com. & Mod.	X	
		Unit Hydrograph & Loss Rate Optimization	Rainfall-R/O Com. & Mod.	X	
		Water Surface Profile Data Edit	Data Ga./Corr.	X	
		Water Surface Profiles (HEC II) (Modified)	River Hydrau.	X	(Modification of COE Program)
Idaho	Dept. of Water Res.	Snake River Simulation Prog.	Reservoir-Water Supply Management Resources Plan-ning	X	
		Bear River Simulation Prog.	Res.-Water Supply Man. Res. Planning	X	

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Idaho	Dept. of Water Res. (Cont.)	Snake Plain Groundwater Model	Res.-Water Supply Man. Groundwater Res. Planning		University of Idaho
		Boise Valley Groundwater Mod.	Res.-Water Supply Man. Groundwater Res. Planning	X	(With University of Idaho)
		Boise River Ecologic Model	Res.-Water Supply Man. Water Quality Res. Planning		Tetratech, Inc.
Illinois	Dept. of Transportation Division of Waterway	Flood Hydrograph Package (HEC I)	Public Works		U.S. Army Corps of Engineers
		Water Surface Profiles (HEC II)	Public Works		U.S. Army COE
		Multiple Correlation & Regression Analysis	Rainfall-R/O Com. & Mod.	X	
		Log Pearson Type III High & Low Frequency Analysis	Rainfall-R/O Com. & Mod.	X	
		Implicit Dynamic Flood Routing	River Hydrau.		National Weather Ser.
		Explicit Natural Streamflow Routing	River Hydrau.	X	
	State Water Survey	Illudas - Urban Rain, R/O	Rainfall-R/O Com. & Mod.	X	
		Numerous Groundwater Models	Data Ga./Corr. Groundwater	X	
Kansas	Water Res. Board	Reservoir Daily Quantity & Quality Routing Model	Res.-Water Supply Man. Water Quality	X	

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Kansas	Water Res. Board (Cont.)	Basin Hydrology Simulator	Res.-Water Supply Man. Rainfall-R/O Com. & Mod. Aquifer Simulation Watershed Simulation		USGS & Kansas Univ.
		Pricing Policy Model	Economic Analysis	X	
Kentucky	Dept. of Natural Res & Environmental Protection Div. of Water Res.	Unit Response Channel Routing	Res.-Water Supply Man.		USGS
		Reservoir Flood Routing	Public Works Data Ga./Corr.		Soil Conservation Ser.
		Water Surface Profiles (HEC II)	River Hydrau		US Army COE
		Reservoir Routing Programs	Public Works	X	(With USGS)
Maryland	Water Resources Administration	WSP-2	River Hydrau		Soil Conservation Ser.
		TR-20	Res.-Water Supply Man. Rainfall-R/O Com. & Mod.		Soil Conservation Ser.
		WRA-1	Data Corr.	X	
		WRA-2	Data Corr.	X	
		WRA-3	Res.-Water Supply Man.	X	
Massachusetts	Water Res. Comm. Div. of Water Res.	Ipswich River Model	Res.-Water Supply Man. Water Quality		USGS

HYDROLOGIC MODELS USED BY STATE AGENCIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Mass.	Water Res. Comm. (Cont.)	Cape Cod Groundwater Model	Res.-Water Supply Man. Groundwater		USGS
	Div. of Water Pollution Control	Steady State River Quality	Water Quality		R&D Contract by Div.
		Steady State Estuary Model	Water Quality		R&D Contract by Div.
		Time Variable Hydrodynamic and Water Quality Models	Water Quality		R&D Contract by Div.
Montana	Dept. of Natural Res. & Conservation	State of Montana Water Planning Model	Rainfall-R/O Com. & Mod.		Montana State Univ.
Nebraska	Natural Res. Commission	EPA-QUAL-1	Water Quality		Texas Water Development Board & EPA
		EQP-QUAL-2	Water Quality		Texas Water Development Board & EPA
		HISARS	Data Ga./Corr. Rainfall-R/O Com. & Mod.	X	
		Water Surface Profiles (HEC-II)	River Hydrau.		US Army COE
North Dakota	State Water Commission	Flood Hydrograph	Rainfall-R/O Com. & Mod.	X	
		Benefit-Cost Ratio	Economic Ana.	X	
		Canal Earthwork	Public Works		Bureau of Reclamation
		Streamflow Correlation	Data Ga./Corr.		US Army COE
		River Basin Model	Res.-Water Supply Man.	X	
		Dam Earthwork	Public Works	X	
		Flood Routing	Res.-Water Supply Man.	X	

HYDROLOGIC MODELS USED BY STATE AGENCIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
West Va.	Water Resources	EPA QUAL II	Sanitary Eng. Water Quality		EPA
		EPA Horne	Sanitary Eng. Water Quality		EPA
		Curve Fittings & Model Selection Methods	Rainfall-R/O Com. & Mod. River Hydrau.		PhD Dissertation, W. Va. University
Wisconsin	Dept. of Natural Res	Low Flow Study for Water Quality	Water Quality		USGS
Wyoming	State Engineer's Office	Water Rights Information System	Water Rights		State Dept. of Central Data Proc.
		Surface Water System	Res.-Water Supply Man. Conservation Res. Planning Economic Ana.		U. of Wyoming Water Resources Research Institute
		Reservoir Operation Model	Res.-Water Supply Man. Conservation Economic Ana. Res. Planning		State Dept. of Central Data Proc.
		Platte River Hydrologic Model	Res.-Water Supply Man. Conservation Economic Ana. Res. Planning		U. of Wyoming Water Resources Research Institute
		Lower Platte River Ground-Water Model	Res.-Water Supply Man. Conservation Economic Ana. Groundwater Res. Planning		USGS

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Texas	Water Development Board (Cont.)	RESOP	Res.-Water Supply Man.	X	
		GWSIM	Res.-Water Supply Man. Estuarine Water Quality	X	
		IMAGE-1	Estuarine Water Quality	X	
		AL-3	Res.-Water Supply Man.		Water Res. Engr., Inc.
		RIVTID	Flood Fore. River Hydrau.		Water Res. Engr., Inc.
		MOM	Water Quality	X	
Vermont	Water Res. Board	DOWIN	River Hydrau.		TRW, Inc.
Virginia	State Water Control Board	Water Quality Mathematical Model - Streams, Estuaries	Water Quality	X	(With Va. Institute of Marine Science)
		Water Quality Mathematical Model - Waste Discharge Permits	Water Quality	X	(With Va. Institute of Marine Science)
		Groundwater Simulation Digital Model	Groundwater	X	(With USGS Water Div.)
Washington	Dept. of Ecology	Columbia Basin (3 models)	Groundwater		USGS
		Odessa	Groundwater		USGS
		Walla Walla	Groundwater		USGS
		Pullman	Groundwater		USGS
		Spokane	Groundwater		USGS
		Yakima	Res.-Water Supply Man.		Wash. State Water Res. Center

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Puerto Rico	Aqueduct & Sewer Authority (Cont.)	STATPAC	Res.-Water Supply Man. Data Ga/Corr. Economic Ana.		USGS
Texas	Water Development Board	SIMLYD-II	Res.-Water Supply Man.	X	
		SIM-IV	Res.-Water Supply Man. Economic Ana.		Water Res. Engineers Inc.
		MOSS-IV	Data Ga/Corr. Rainfall-R/O Com. & Mod.		Roy Beard, Center for Res. in Water Res., U of Texas/Aus
		FILL-IN	Data Ga/Corr. Rainfall-R/O Com. & Mod.		Water Res. Engr., Inc.
		QUAL-II, DOSAG	Water Quality		EPA - Water Res. Engineers, Inc.
		LAKECO	Res.-Water Supply Man. Water Quality		Water Res. Engr., Inc.
		ECOSYM	Economic Ana.	X	
		HYD-I	Public Works Res.-Water Supply Man.		Water Res. Engr., Inc.
		SAL-I	Res.-Water Supply Man. Water Quality Estuarine Hy.		Water Res. Engr., Inc.
		ESTECO	Res.-Water Supply Man. Water Quality Estuarine Hy.		Water Res. Engr., Inc.

HYDROLOGIC MODELS USED BY STATE AGENCIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Ohio	Dept. of Natural Res	Water Surface Profiles (HEC-II)	River Hydrau.		US Army COE
		Regional Frequency Computation (L-2350)	Data Ga./Corr.		US Army COE
Penn.	Dept. of Environmental Res. Bureau of Res. Programming	Water Surface Profiles	River Hydrau.	X	
		Water Surface Profiles (HEC-II)	River Hydrau.		US Army COE
		Synthetic Hydrograph	Flood Forecasting	X	
		Reservoir Routing	Public Works	X	
		Average Annual Damage Comp.	Economic Ana.		US Army COE
		Culvert Design	Public Works		Bureau of Public Road
		Flood Frequency Analysis	Flood Fore.		Penn. State Univ.
		Precipitation Study for Pa.	Data Ga./Corr.	X	
Puerto Rico	Aqueduct & Sewer Authority	P.R. Hydrological Rainfall Simulation	Res.-Water Supply Man. Data Ga./Corr. Rainfall-R/O Com. & Mod.		Prepared for the Commonwealth by Singer Information Ser.
		P.R. Hydrologic Data Bank	Res.-Water Supply Man. Sanitary Engineering Water Quality Data Ga./Corr. Rainfall-R/O Com. & Mod. Conservation		Prepared for the Commonwealth by Singer Information Ser.
		PIPENET (ICES System)	Res.-Water Supply Man.		MIT, Cambridge, Mass.

APPENDIX D

COMPUTERS IN WATER RESOURCE USE BY STATE AGENCIES

Appendix D lists the computers used by each state water resource agency, indicating utilization (whether shared or dedicated), location if not in-house, total use in hours per week, and percentage of total utilization for water resource activities.

COMPUTERS IN WATER RESOURCE USE BY STATE AGENCIES

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Ark.	Dept. of Commerce Div. of Soil & Water ~~Resources~~	IBM 370	X			Univ. of Arkansas		Little (in Development Stage)
Calif.	Dept. of Water Resources	CDC 3300	X		X	Sacramento	115	20
		IBM 1130 tied to 360/195 in Suitland, Md.		X		Res. Bldg. shared with Natl. Weather Service		100
		Nova 1220		X	X	Sacramento		100
	State Water Project	UNIVAC 418		X	X	Sacramento	168	100
		HP 2114		X	X	Sacramento	168	100
		HP 2116		X	X	Sacramento	168	100
		HP 2110		X	X	Sacramento	168	100
		GE 4040		X	X	Sacramento	168	100
		Honeywell 316		X	X	Sacramento	168	100
		DMI 620		X	X	Sacramento	168	100
		PDP 85		X	X	Sacramento	168	100

STATE	AGENCY	COMPUTER	UTILIZATION: SHARED	UTILIZATION: DEDICATED	LOCATION: IN HOUSE	LOCATION: ORGANIZATION & CITY	TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
		CDC 6400	X			U.C. Berkeley	1	Unknown
Idaho	Dept. of Water Resources	IBM 370/145	X			Idaho State Office Bldg., Boise (State Auditor's Office)	1	Unknown
Ill.	Dept. of Transportation. Div. of Waterway	IBM 360/155	X		X		40	
	State Water Survey	WANG 3300		X	X		50 (several consoles)	100
		IBM 360	X			Univ. of Ill.	20	Unknown
Kan.	Water Resources Board	Honeywell 635		|		Kansas Univ. Computation Center	2-10	100
Ken.	Dept. for Natural Resources, Div. of Water Resources	IBM 370/165	X		X		Shared by all State Agencies	1
Md.	Dept. of Natural Resources	IBM 370/155	X					$3000/mo for time & storage
	Water Resources Administration	IBM 370/168 or 155	X			McLean, Va.	Unknown	20 hrs/wk
Mass.	Water Resources Comm. Div. of Water Res.	IBM 370/145	X			Dept. of Public Works, Boston		
	Div. of Water Pollution Control	IBM 370/145	X			Dept. of Public Works, Boston	5-10	
Miss.	Board of Water Commissioners	Unknown				Waterways Exper. Station, Vicksburg		Unknown

COMPUTERS IN WATER RESOURCE USE BY STATE AGENCIES

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs./wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Mont.	Dept. of Natural Resources & Conservation	IBM 370/145	X			Dept. of Admin.		
		Sigma 7	X			Mont. State Univ.		
N.D.	State Water Comm.	IBM 370/145	X			State Central Data Processing, Highway Bldg.	110	1.5
		IBM 360/20	X			State Central Data Processing, Hgwy. Bld.	40	0
Ohio	Dept. of Natural Resources	IBM 370/158				State of Ohio Data Center	5 min.	5
Pa.	Dept. of Environ. Resources Bureau ~~of Resources Prog.~~	Burroughs B-6700	X			Dept. of Transpor.	3	100
Puerto Rico	Aqueduct & Sewer Authority	IBM 360/40	X		X		100	0
		IBM 370	X			P.R. Highway Authority Scientific Cen.		0
Tex.	Water Development Board	UNIVAC 1106	X		X		125	38
Vt.	Water Resources Board	IBM 370/158		X		Bethesda, Md.	20	100
		IBM 360/148	X		X			Minimal

STATE	AGENCY	COMPUTER	UTILIZATION: SHARED	UTILIZATION: DEDICATED	LOCATION: IN HOUSE	LOCATION: ORGANIZATION & CITY	TOTAL USE (Hrs./wk)	% of total utilization for water res. activities
Va.	Dept. of Conservation & Economic Development, State Water Control Board	IBM 370/158	X			Private Contractor in Richmond		
		IBM 370/158	X			Va. Dept. of Motor Vehicles, Richmond		
		IBM 370/145	X			Va. Commonwealth Univ., Richmond		
		IBM 360/50	X					
	Va. State Water Control Board, Bureau of Water Control Management		X	X		Va. Commonwealth Univ. of Richmond	2	2
Wash.	Dept. of Ecology	USGS & WSU Facilities used						
W. Va.	Water Resources	IBM 360-series				W.V.U., Morgantown, W. Va.		
Wisc.	Dept. of Natural Resources (Figures in last column are total DNR Water Resources terminal time; do not include total usage for out of house computers.)	IBM 155	X			Boeing Computer Services, Va.	10	
		IBM 360/155 IBM 370/158	X			Optimum Systems Inc. Bethesda	30	
		UNIVAC 1110	X			Univ. of Wisc. Madison	15	
		UNIVAC 9400		X	X		(35 water resources) 140	25

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
		IBM 370	X			Dept. of Admin. Madison	7	
		Cal. Comp. Plotter	X			Dept. of Trans. Madison	1	
Wyo.	State Engineer's Office	Sigma 7	Unknown to user	Unknown to user		Univ. of Wisc.	Unknown to user	Unknown to user
		IBM 370/155				State Dept. of Central D.P.		

APPENDIX E

WATER RESOURCE ACTIVITIES OF STATE WATER RESOURCE RESEARCH INSTITUTES

Appendix E summarizes the activities of state Water Resources Research Institutes by percentage of time devoted to different areas of research.

WATER RESOURCE ACTIVITIES OF STATE WATER RESOURCES RESEARCH INSTITUTES

STATE	AGENCY — ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGMT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Calif.	Water Resources Center	Does not conduct in-house research.														
Colo.	Dept. of Earth Resources					10	15	5	40		5				25	
Hawaii	Water Resources Research Center	X	X	X	X	X	X	X			X	X			X	
Idaho	Water Resources Research Institute	1	2	3	2	20	3+	3	1		10	15	15		3	(1)
La.	Water Resources Research Institute	5	10	15		10	25	5			5	15			10	(2)
Maine	Environmental Studies Center				10	50	20					10			10	
Mont.	Mont. U. Joint Water Resources Res. Center			X	X	X	X	X	X		X	X			X	
Neb.	Water Resources Research Institute				20	30		25				10			15	

(1) Public Attitude Surveys 2%
Fishery Res. 15%
Legal 5%

(2) Deep Well Waste Disposal

X = Mentioned, but no percentage figures given.

STATE	AGENCY — ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGMT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Nev.	Water Resources Res. Center, Desert Res. Institute	2.8	0.5	4.5	0.3	17.8	15.9	2.4	1.0	17.7	1.1	0.9	20			(3)
Puerto Rico	Water Resources Research Institute		12.5	25	12.5	12.5									12.5	(4)
S.C.	Clemson Univ. Water Res. Res. Institute			15		30					10	15			30	
Tenn.	Water Resources Research Center	Research Report on Remote Sensing														

(3) Geothermal Energy 5.1%
Radionuclide Transport 10%

(4) Identification of Water Resource Problems and Needs 12.5%
Hydrogeologic Studies 12.5%

APPENDIX F

HYDROLOGIC MODELS USED BY STATE WATER RESOURCE RESEARCH INSTITUTES

Appendix F lists hydrologic models used by the state Water Resources Research Institutes. Applications and origins of the models are also included.

HYDROLOGIC MODELS USED BY STATE WATER RESOURCES INSTITUTES F-1

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Colo.	Dept. of Earth Resources, Colo. State Univ.	CSU Version of Kentucky	Rainfall-R/O Computation & Mod. Snowmelt		Kentucky Version of Stanford Watershed Model
		Leavesley CSU Model	Rainfall-R/O Com. & Mod. Snowmelt	X	
		Leaf Model	Rainfall-R/O Com. & Mod. Snowmelt		U.S. Forest Service
		ELM	Ecological Research Related to Water		Total Ecosystem Model Incl. Hydrologic Syste
		SOGCY	Rainfall-R/O Com. & Mod. Ecological Res. Re. to Water		AEC, ET Model
Hawaii	Water Resources Res. Center, University of Hawaii	Hawaii Watershed Model, modified from Kentucky Watershed Model	Initial investigation done in testing stage	X	
		Conceptual non-linear hydrograph simulation model	Preliminary report done in testing stage	X	
		Instantaneous unit hydrograph model	Study completed	X	
		Several water quality models	Study progress	X	
Idaho	Water Resources Research Institute	Ralston's Raft River Model	Groundwater	X being dev.	

HYDROLOGIC MODELS USED BY STATE WATER RESOURCES INSTITUTES F-2

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
		Snake Plain Model	Groundwater	X being dev.	
		An array of 3-4 dozen standardized statistical and hydrological/hydraulic models. (Count as 42)		X	
Indiana	Water Resources Research Center Purdue University	Stanford Watershed			Stanford Univ.
		Streeter-Phillips			
La.	La. Water Resources Research Institute La. State Univ. & Agricultural & Mechanical College	Lafourche Bayou Hydraulic	Flood Fore. Ecological Res. Re. to Water River Hydrau. Water Quality	X	
		Qual 1 - Modify	Water Quality		Texas Water Board
		Mississippi River Salt Water Intrusion	Water Quality River Hydrau.	X	
		Storage of Water in Saline Aquifer	Res.-Water Supply Man. Water Quality	X	
		Movement of Wastes in Deep Well Disposal Projects	Deep Well Waste Disposal		
Montana	Montana. Univ. Joint Water Resources Research Center	Water Planning Model	Public Works Design Res.-Water Supply Man.	X	Now being used by Mont. State Dept. of Natural Resources
		Reservoir Operations Model	Res.-Water Supply Man.	X	Produced for Mont. State Dept. of Natura Resources

HYDROLOGIC MODELS USED BY STATE WATER RESOURCES INSTITUTES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Nebraska	Water Resources Research Institute Univ. of Neb. Lincoln	Stanford			Stanford Univ.
		Nebraska Hydrologic Model		X	
Nevada	Center for Water Resources Research Desert Research Institute, Univ. of Nevada System	Jacobsen Water Chemistry Prog.	Water Quality		Penn State Univ.
		Cooley SIP	Groundwater Geothermal Energy Radionuclide Transport	X	
		Stanford Watershed Model	Rainfall-R/O Com. & Mod.	Modifications	Stanford Univ., Palo Alto, California
		Carson-Truckee Simulation Model	Res.-Water Supply Man. Sanitary Engr. Snowmelt River Hydrau Economic Ana	X	
		Frequency Distribution Selector	Flood Fore. Rainfall-R/O Com. & Mod.	X	
		Water Distribution Network Analysis	Public Works	Modifications	Dr. Don Wood, Univ. of Kentucky
		Finite Difference River Flow	River Hydrau	X	
		Wastewater Treatment Plant Performance Variability	Sanitary Engr.	X	
		Serial Correlation, Spectral and Cross-Spectral Analysis	Data Correlation Water Quality	X	
		Sequential Flow Simulator	Flood Fore. Data Corr.		U.S. Corp. of Engineer Hydrologic Engr. Cente Davis, Calif.

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
		DOSAG	Sanitary Engr Water Quality	Modifications	Environ. Dynamics, Mod of Texas Water Dev. Board
		Unsteady Finite Element Model	Groundwater Hydraulics	X	
		Steady State Finite Element Model	Groundwater Hydraulics	X	
So. Caro.	Water Resources Research Institute Clemson Univ.	Stanford Watershed Model (Kentucky Version), Ligon	Rainfall-R/O Com. & Mod.		Dr. L. Douglas James, Univ. of Ken. (now GI
		Snyder Basin Yield Model, Wilson, Ligon, Law	Rainfall-R/O Com. & Mod.		Mr. W.M. Snyder, ARS, USDA, Athens, Ga.

APPENDIX G

COMPUTERS IN WATER RESOURCE USE BY STATE WATER RESOURCE RESEARCH INSTITUTES

Appendix G lists the computers used by each state Water Resources Research Institute, indicating utilization (whether shared or dedicated), location if not in-house, total use in hours per week, and percentage of total utilization for water resource activities.

COMPUTERS IN WATER RESOURCE USE BY WATER RESOURCES RESEARCH INSTITUTES

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Colo.	Dept. of Earth Res. Colo. State Univ.	CDC 6400	X		X		10 by this dept.	50
		WANG 520			X		20	5
		HP 35			X		10	85
Hawaii	Water Resources Research Center Univ. of Hawaii	Aloha System	X	X	X		Unknown to user	Unknown to user
		IBM 7040/1401	X	X	X		Unknown to user	Unknown to user
		IBM 360/65	X	X	X		Unknown to user	Unknown to user
Idaho	Water Resources Research Insititute	Both digital and analog models are used. We operate on 3 major computer center facilities, a number of desk top programs & a few terminals.						
Ind.	Water Resources Research Center, Purdue Univ.	CDC 6500/ IBM 7094						
		CDC 1700 & 2 EAI 680 analog						
		DEC-PDP-11 Other computers as well						
La.	Water Resources Research Institute La. State Univ.	IBM 360/65	X		X		84.6	<5
Maine.	Environ. Studies Center, Univ. of Maine at Orono	IBM 370/145			X		160	2

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Mont.	Mont. Univ. Joint Water Resources Research Center	Xerox Sigma 7		X		MSU - Bozeman	112	Unknown to user
		IBM 1620		X		Mont. College of Mineral Science & Tech., Butte	Unknown to user	Unknown to user
		IBM 360		X		State of Montana Helena, Mont.	Unknown to user	Unknown to user
		Digital Eq. Corp. DEC 10		X		Univ. of Mont. Missoula, Mont.	Unknown to user	Unknown to user
Neb.	Water Resources Research Institute Univ. of Neb. Lincoln	IBM 360/65						
Nev.	Desert Research Institute, Center for Water Resources Research	CDC 6400	X			Univ. of Nev. System, Reno, Nev.	96	5
		CDC 6400	X			US AEC, Las Vegas, Nev.	96	1
		WANG	X		X		35	100
		HP-45 (2)	X		X		30	100
		HP-35 (4)	X		X		30	100
Puerto Rico	Water Resources Res. Institute, U. of PR	IBM 360	X			U.P.R.		<1
S.C.	Clemson Univ., Water Res. Res. Institute	IBM 370/158VS		X	X		41.4	5

APPENDIX H

SUMMARY OF RESPONSES FROM UNIVERSITIES

Appendix H summarizes the water resource activities of universities by percentage of time devoted to different areas of research. Also included are the hydrologic models and computers utilized.

STATE	AGENCY / ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGNT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Kan.	Univ. of Kansas Chem. & Pet. Engr.												20			
Ken.	Univ. of Kentucky Agri. Engr.			20			30	40				10				
Mich.	Mich. State Univ. Civil Engr.												100			
Neb.	% of personal research time Univ. of Nebraska Agri. Engr.												5			
N.C.	N.C. State Univ. Civil Engr.					50					50					
	N.C. State Univ. Bio & Agri. Engr.						40	40								
Ohio	Ohio State Univ. Civil Engr.					10	5	20	5		10					
	Ohio State Univ. Agronomy															(1)

(1) Aquifer Characteristics Modeling 10%

STATE	AGENCY / ACTIVITIES CONDUCTED (% of time for Res.)	FLOOD FORECASTING	PUBLIC WORKS DESIGN	RESERVOIR-WATER SUPPLY MGNT.	SANITARY ENGINEERING	WATER QUALITY	DATA GATHERING & CORRELATION	RAINFALL-RUNOFF COMPUTATION & MODELING	SNOWMELT	CONSERVATION	RIVER HYDRAULICS	ECONOMIC ANALYSIS	GROUNDWATER	WATER RIGHTS	RESOURCES PLANNING	OTHER
Ind.	Purdue Univ. Agri. Engr.						20	25								
Tex.	Univ. of Tex/Austin Mech. Engr.			20		20						20				(2)
Utah	Utah State Univ. Forest Science					50		(3) 50								
Va.	VPI & State Univ. Agri. Engr.					5	30	60							5	(4)

(2) One project only.
(3) Modeling only.
(4) Soil Moisture Accounting (Irrigation Forecasting)

HYDROLOGIC MODELS USED BY UNIVERSITIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Kansas	Univ. of Kansas Chem. & Pet. Engr.	Basin Hydrology Simulator	Groundwater Confined and Unconfined Aquifers Flow in Un-Saturated Zone	X	
		Flow in Unsaturated Zone	Groundwater Confined and Unconfined Aquifers Flow in Un-Saturated Zone	X	
		Aquifer Simulator	Groundwater Confined and Unconfined Aquifers Flow in Un-Saturated Zone	X	
Kentucky	Univ. of Ken. Agri. Engr.	4 Parameter Water Yield Model	Res.-Water Supply Man. Rainfall-R/O Com. & Mod. Ecological Research Related to Water	X	
		Thomas-Fiering	Res.-Water Supply Man. Rainfall-R/O Com. & Mod. Ecological Res. Re. to Water		Harvard

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Michigan	Michigan State Univ. Civil Engr.	Finite Element - Unsteady Groundwater Flow	Groundwater Management	X	
Nebraska	Univ. of Nebraska	Recharge Simulation	Groundwater Recharge	X	
No. Caro.	N.C. State Univ. Civil Engr.	Implicit Hydrodynamic Model	River Hydrau.	X	
		Explicit Water Quality	Water Quality	X	
	N.C. State Univ. Bio. & Agr. Engr.	SSARR	Rainfall-R/O Com. & Mod.		COE
		Many others being tested.			
Ohio	Ohio State Univ. Civil Engr.	O.S.U. Version of the Stanford Watershed Model	Water Quality Rainfall-R/O Com. & Mod. Snowmelt	Partially	Stanford Group Hydrocomp
		HEC II	River Hydrau.		COE
		Acid Mine Drainage Unit Source Models	Water Quality Economic Ana.	X	
	Ohio State Univ. Agronomy	Mathematical (Numerical Analysis)	Aquifer Characteristics Mod. Aspect Only	Basically modification	"Other" with some "In house."
Ind.	Purdue Univ. Agric. Engr.	Distributed Parameter Watershed Model	Rainfall-R/O Com. & Mod.	X	
Texas	Univ. of Texas/Austin Mechanical Engr.	Out of Kilter Algorithm	Network Flow Optimization Algorithm (Res.-Water Supply Man., Economic Ana.)	X	

HYDROLOGIC MODELS USED BY UNIVERSITIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
		Gain	Res.-Water Supply Man. Water Quality Economic Ana.	X	
		CAPEX	Economic Ana.	X	
Utah	Utah State Univ. Forest Science	No name	Rainfall-R/O Modeling		
Virginia	VPI & State Univ. Agri.Engr.	Stanford VPI & SU Modification	Water Quality Rainfall-R/O Com. & Mod. Ecological Res. Re. to Water	X	Stanford University
		Kentucky Watershed Model	Rainfall-R/O Com. & Mod.		Univ. of Kentucky (Mod. of Stanford Model
		USDA Hydrograph Model	Rainfall-R/O Com. & Mod.		USDA Hydrograph Lab Beltsville, Md.
		Soil Water Model	Soil Moisture Accounting (Irrigation Forecasting)	X	

COMPUTERS IN WATER RESOURCE USE BY UNIVERSITIES

STATE	AGENCY	COMPUTER	UTILIZATION: SHARED	UTILIZATION: DEDICATED	LOCATION: IN HOUSE	LOCATION: ORGANIZATION & CITY	TOTAL USE (Hrs./wk)	% of total utilization for water res. activities
Kansas	Univ. of Kansas Chem. & Pet. Engr.	Honeywell 625 series			X	Services entire	160	Unknown
Ken.	Univ. of Kentucky Agri. Engr.	IBM 360/65			X		personal usage 14 hrs during last year	95
Mich.	Mich. State Univ. Civil Engr.	CDC 6500					168	<1
Neb.	Univ. of Neb. Agri. Engr.	IBM 360/65		X	X		personal usage 1	100
N.C.	N.C. State Univ. Civil Engr.	IBM 360					1	
	N.C. State Univ. Bio. & Agri. Engr.	IBM 370/165	X			TUCC (Triangle Univ. Computation Center)	?	<1
Ohio	Ohio State Univ. Civil Engr.	IBM 370/165				Terminals throughout campus		
	Ohio State Univ. Agronomy	IBM 360/75				Main campus	1.	30
Ind.	Purdue Univ. Agri. Engr.	PDP-11/20	X				100	5
Tex.	Univ. of Tex/Austin Mech. Engr.	CDC 6500					100	Unknown
		CDC 6600		X			n/a	n/a

COMPUTERS IN WATER RESOURCE USE BY UNIVERSITIES

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Utah	Utah State Univ. Forest Science	Burroughs 7600	Unknown	Unknown		USU	Unknown	Unknown
		WANG 600 desk-top mini-com puter	X			LAB	25% of time	80
Va.	VPI & State Univ. Agri. Engr,	IBM 370						

APPENDIX I

SUMMARY OF RESPONSES FROM PRIVATE CONSULTANTS

Appendix I lists the hydrologic models and computers utilized by the private contractors surveyed.

HYDROLOGIC MODELS USED BY PRIVATE CONSULTANTS

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
Md.	Wilson T. Ballard	Mathematical Models	Flood Control	X	
Md.	Dalton-Dalton-Little-Newport	HEC II	Flood Plain Delineation		COE
Md.	Hittman	Water Demand Forecasting Models		X	
		Drainage Design Models		X	
		EPA Stormwater Management Model			EPA
Md.	Maty, Childs, and Associates	SCS series of Models, inc. TR-20			SCS
		Backwater and Floodwater Models			TAMS
		Bureau of Roads Programs			Bureau of Roads
		Log-Pearson Flood Distribution Programs			Log-Pearson
		EPA Programs	Water Quality		EPA
Md.	Rummel, Klepper and Kahl	SCS package, incl. TR-20 & 8 other Programs	Flood Routing Unit Hydrograph Reservoir Studies		SCS
Md.	Whitman, Requardt & Associates	HEC II			COE
		Package of Small Storm Drainage & Backwater Models			

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs./wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
Md.	Wilson T. Ballard Baltimore	IBM 1130	X		X		35-40	10
Md.	Dalton-Dalton-Little-Newport, Baltimore	Limited				Mail data to Cleveland office		
Md.	Hittman Columbia	IBM 360				EPA, Phila., Pa.		Very Little
		UNIVAC 1108				Computer Scientific Corp., Silver Spring, Md.		Very Little
Md.	Maty, Childs & Assoc. Baltimore	IBM 1130			X		2 shifts/ day	A few hrs./ month
Md.	Rummel, Klepper & Kahl, Baltimore	IBM 1130			X			< 5 hrs/wk
		1 mill. byte storage machine			X			
Md.	Whitman, Requardt & Assoc., Baltimore	IBM 360	X			Martin Co.	Cannot be measured accurately	
		IBM 370/135 145,or 155	X			Martin Co.	Cannot be measured accurately	

APPENDIX J

SUMMARY OF ACTIVITIES AND BUDGETS OF MAJOR FEDERAL WATER AGENCIES

Appendix J gives information on the activities, location and detailed budget of each of the eleven major federal water resources research agencies.

United States Department of Agriculture

Agricultural Research Service

A. Activities

1. Watershed development research

   a. Research using experimental watersheds & changing various conditions (ex. effects of land use, watershed management schemes on runoff, streamflow, etc.)

   b. Development of methods of prediction of sediment properties & sources

   c. Control of reservoir sedimentation

   d. Erosion control

   e. Hydraulic design

2. Soil and water conservation and development research

   a. Recharging groundwater; sewage filtering

   b. Water harvest

   c. Irrigation

   d. Improving agricultural drainage systems

   e. Reduction of salinity damage

   f. Improving water-use efficiency on non-irrigation lands

   g. Energy conversion

3. Agricultural pollution

   a. Disposal of animal waste

   b. Control of pesticides

   c. Control of fertilizer pollution

   d. Development of pesticide pollutant equipment

   e. Disposal of sludge

   f. Elimination of water pollution from processing of agricultural products

4. Remote sensing research

5. Production efficiency research - improved agricultural products & facilities

B. Locations

1. Beltsville, Md. Regional Office

2. Peoria, Ill. Regional Office

3. New Orleans, La. Regional Office

4. Berkeley, Calif. Regional Office

DEPARTMENT OF AGRICULTURE

Agricultural Research Service

Research Category		FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
		Allocation of Funding by Fiscal Years (thousands of dollars)		
II.	Water Cycle			
A.	General	1,155	1,336	1,057
B.	Precipitation	466	597	605
C.	Snow, ice, and frost	177	277	120
D.	Evaporation and transpiration	863	902	936
E.	Streamflow and runoff	387	406	464
F.	Groundwater	238	147	165
G.	Water and soils	642	609	656
I.	Water in plants	249	203	131
J.	Erosion and sedimentation	1,864	1,961	2,196
	SUBTOTAL	6,041	6,438	6,330
III.	Water Supply Agumentation and Conservation			
B.	Water yield improvement	603	294	315
C.	Use of water of impaired quality	1,326	1,383	1,319
D.	Conservation in domestic & municipal use	20	5	20
F.	Conservation in agricultural use	1,339	2,539	2,573
	SUBTOTAL	3,288	4,221	4,227
IV.	Water Quantity Management and Control			
A.	Control of water on the surface	2,040	2,129	1,957
B.	Groundwater management	599	315	341
D.	Watershed protection	1,031	1,011	1,055
	SUBTOTAL	3,670	3,454	3,352
V.	Water Quality Management and Protection			
A.	Identification of pollutants	500	577	577
B.	Sources and fate of pollution	1,209	1,507	1,543
C.	Effects of pollution	190	295	214
D.	Waste treatment processes	2,675	3,766	3,762
E.	Ultimate disposal of wastes	231	341	412
F.	Water treatment and distribution	74	77	67
G.	Water quality and distribution	737	849	948
	SUBTOTAL	5,616	7,412	7,523
VII.	Resource Data			
B.	Data Acquisition	98	96	95
C.	Evaluation, processing & publication	75	84	84
	SUBTOTAL	173	180	170

DEPARTMENT OF AGRICULTURE

Agricultural Research Service

Research Category Cont.	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
VIII. Engineering Works			
A. Structures	20	5	20
B. Hydraulics	357	208	217
SUBTOTAL	377	213	237
TOTAL	19,165	21,918	21,848
EXTRAMURAL: (included in categories and Total above)			
Contracts and co-op agreements	92	103	no estimate

SOURCE: Federal Water Resources Research Program for 1972: William S. Butcher, O.W.R.R., p. 5-6.

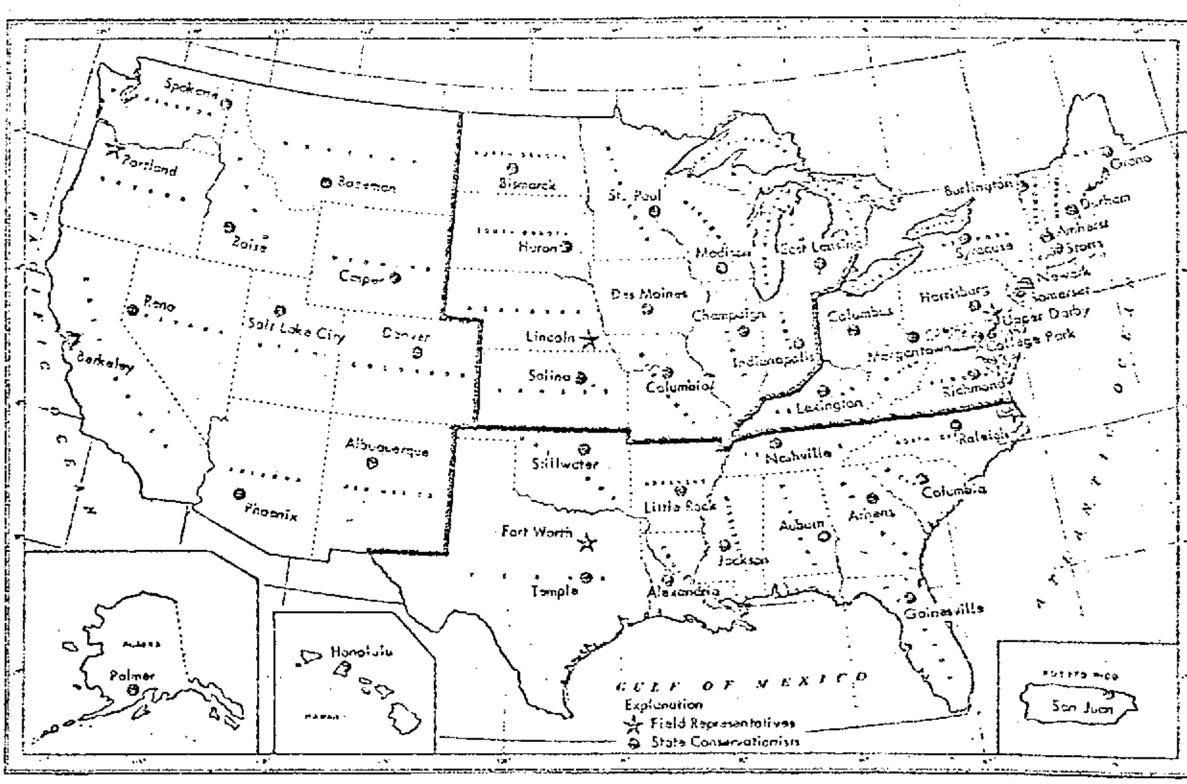
United States Department of Agriculture

Soil Conservation Service

A. Activities

1. Watershed planning
    a. Flood prevention
    b. Water development, utilization & conservation
2. Snow melt & yield - total volume by month
3. Storm runoff as a function of averaged land use, soil type, & rainfall using a statistical analysis of historic storms
4. Stream routing with hydrographs
5. Just beginning in urban hydrology, studying the effects of changed land use
6. Radiation as a measure of water content of snow
7. Using TR-20 on a national scale

B. Locations of Soil Conservation Service Region and Office



Source: <u>The Water Encyclopedia</u>, Water Resources Council, p. 472

C. Budget FY 1973

River Basin Surveys & Investigations	$ 11,855,000
Conservation Operations - Technical Programming, Installation Services & Snow Surveys	138,734,000
Watershed Planning - Small Watershed Project Investigations & Planning	7,786,000
Watershed & Flood Prevention Operations	170,029,000
Total	$328,404,000

Source: The Budget of the U.S. Government, FY 1975

Department of Commerce

NOAA

A. Activities
   1. Hydrologic forecasting
   2. Hydrologic modeling
   3. In charge of research in sensing equipment and data acquisition
   4. Weather data collection & analysis
   5. Lake Hydrology

B. Location
   1. Western Division
      a. Seattle, Wash. - Coast & Geodetic Survey Marine Center
      b. Salt Lake City, Utah - Weather Bureau Regional Office
   2. Central Division
      a. Boulder, Colo. - Research Laboratory
      b. Kansas City, Mo. - Weather Bureau Regional Office, Coast & Geodetic Survey Field Director Headquarters
   3. Southern Division - Fort Worth, Tex. - Weather Bureau Regional Office
   4. Eastern Division
      a. New York - Weather Bureau Regional Office
      b. Norfolk, Va. - Coast & Geodetic Survey Marine Center
   5. Pacific Division - Honolulu, Hawaii - Weather Bureau Regional Office
   6. Alaska Division - Anchorage, Ala. - Weather Bureau Regional Office
   7. Washington, D.C. - National Headquarters

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 18

DEPARTMENT OF COMMERCE

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
I. Nature of Water	-	-	50
II. Water Cycle	1,057	2,304	3,545
III. Water Supply Augmentation & Conservation	83	99	10
IV. Water Quantity Management & Control	-	320	320
V. Water Quality Management & Protection	874	1,343	5,044
VI. Water Resource Planning	1,350	1,140	1,530
VII. Resources Data	1,533	2,448	2,660
IX. Manpower, Grants and Facilities	2,028	2,458	1,007
X. Scientific and Technical Information	-	50	520
TOTAL	6,925	10,162	15,136
Breakdown by office:			
Bureau of Domestic Commerce	83	99	100
National Oceanic and Atmospheric Administration			
National Weather Service	790	805	808
National Marine Fisheries	2,751	2,603	5,708
National Ocean Survey	1,367	1,570	2,870
Office of Sea Grant	1,386	1,895	2,450
International Field Year for the Great Lakes	548	3,240	3,200

Source: *Federal Water Resources Research Program for 1972*, William S. Butcher, O.W.R.R., p. 18

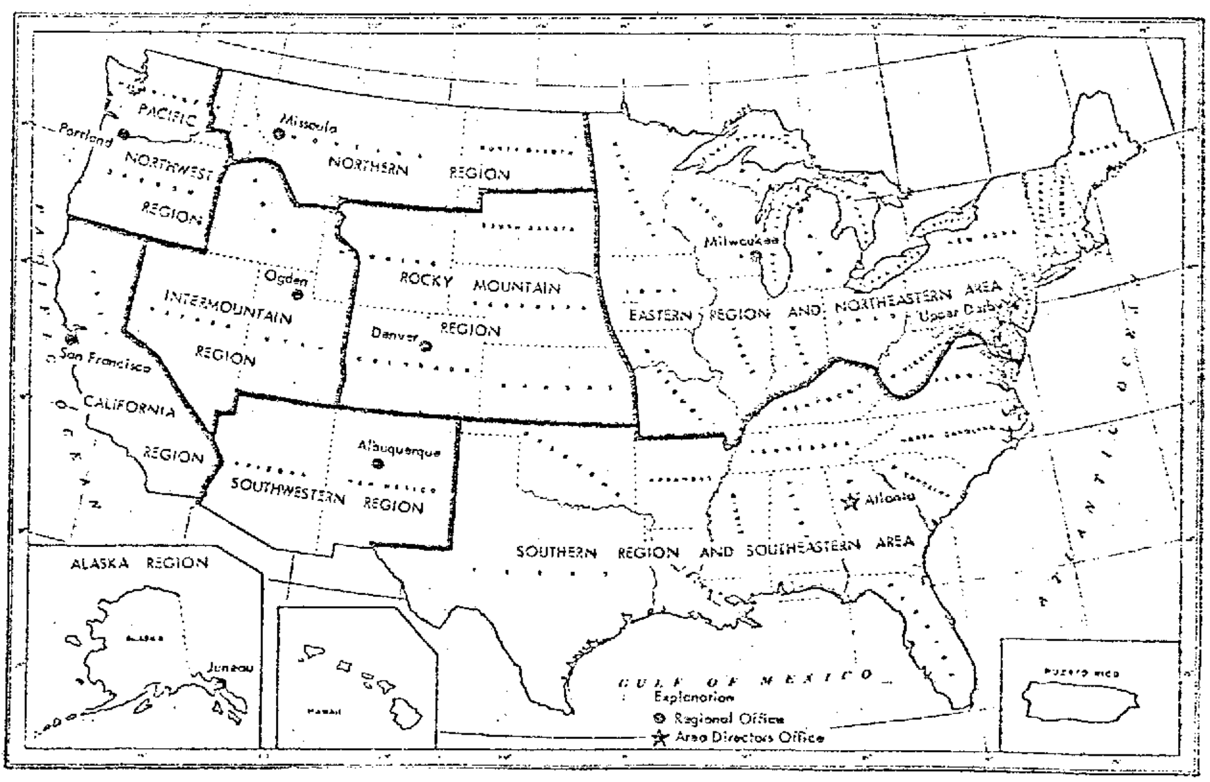
United States Department of Agriculture

Forest Service

A. Activities

1. Water yield improvement
   a. Watershed management for flow control
   b. Influence of vegetative cover on streamflow
   c. Water movement through forest soil
   d. Improvement of snowpack water yield through forest management
2. Watershed protection
   a. Land use effects on watersheds
   b. Minimization of soil disturbances & erosion
   c. Watershed rehabilitation
3. Soil and water quality protection
   a. Research in wetland forest hydrology
   b. Forest pollution control

B. Locations of Forest Service Regions and Offices



Source: The Water Encyclopedia, Water Resources Council, p. 474

DEPARTMENT OF AGRICULTURE

Forest Service

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousand of dollars)		
I. Water Cycle			
A. General	63	261	185
B. Precipitation	12	86	74
C. Snow, ice, & frost	145	399	375
D. Evaporation and transpiration	272	292	376
F. Groundwater	92	22	22
G. Water in soils	446	542	510
I. Water in plants	513	384	377
J. Erosion and sedimentation	169	252	246
SUBTOTAL	1,712	2,238	2,165
I. Water Supply Augmentation and Conservation			
B. Water yield improvement	1,625	1,963	1,889
V. Water Quality Management and Control			
A. Control of water on the surface	494	523	554
C. Effect of man's nonwater activities	184	245	235
D. Watershed protection	605	857	834
SUBTOTAL	1,283	1,625	1,623
V. Water Quality Management and Protection			
B. Sources and fate of pollution	155	186	239
C. Effects of pollution	--	57	150
E. Ultimate disposal of wastes	14	15	15
G. Water quality control	43	52	66
SUBTOTAL	212	310	470
TOTAL	4,832	6,136	6,147

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 16

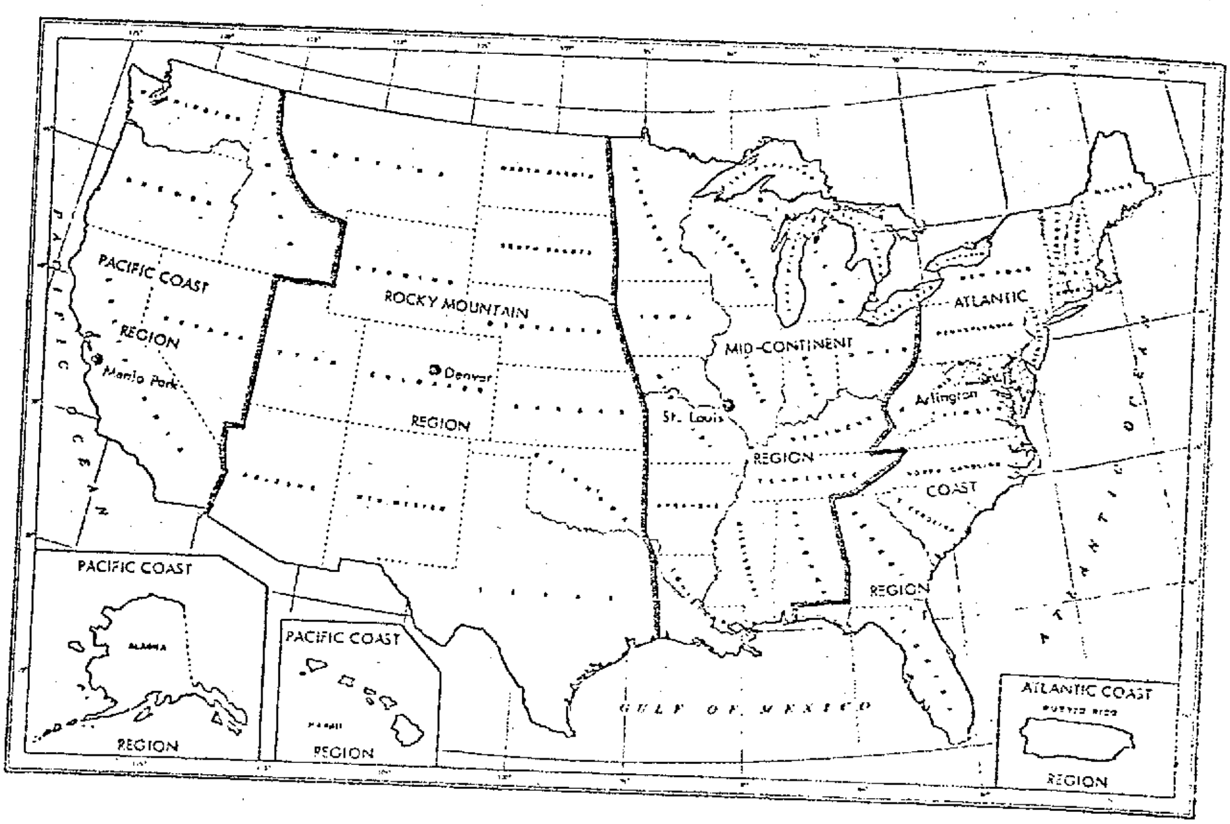
Department of the Interior

Geological Survey

A. Activities

1. Flood magnitude & frequency
2. Hydrologic modeling
3. Remote sensing application in water resource mapping
4. Water losses from evaporation
5. Hydrodynamics of groundwater
6. Estuarine research
7. Urban storm drainage
8. Examination of water requirements of Federal lands
9. Stream and lake and reservoir data acquisition
10. Flood plain mapping
11. Sedimentation

B. Locations of U.S.G.S. Regions and Offices



Source: The Water Encyclopedia, Water Resources Council, p. 510

DEPARTMENT OF THE INTERIOR

Geological Survey

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
I. Nature of Water	0	0	50
II. Water Cycle	7,360	7,680	7,730
III. Water Supply Augmentation and Conservation	540	650	280
IV. Water Quantity Management and Control	1,810	2,053	1,910
V. Water Quality Management and Protection	1,230	1,878	1,930
VI. Water Resources Planning	260	471	130
VII. Resources Data	2,740	1,728	1,960
IX. Manpower, Grants, and Facilities	430	532	550
X. Scientific and Technical Information	60	46	47
TOTAL	14,430	15,038	14,587

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 54.

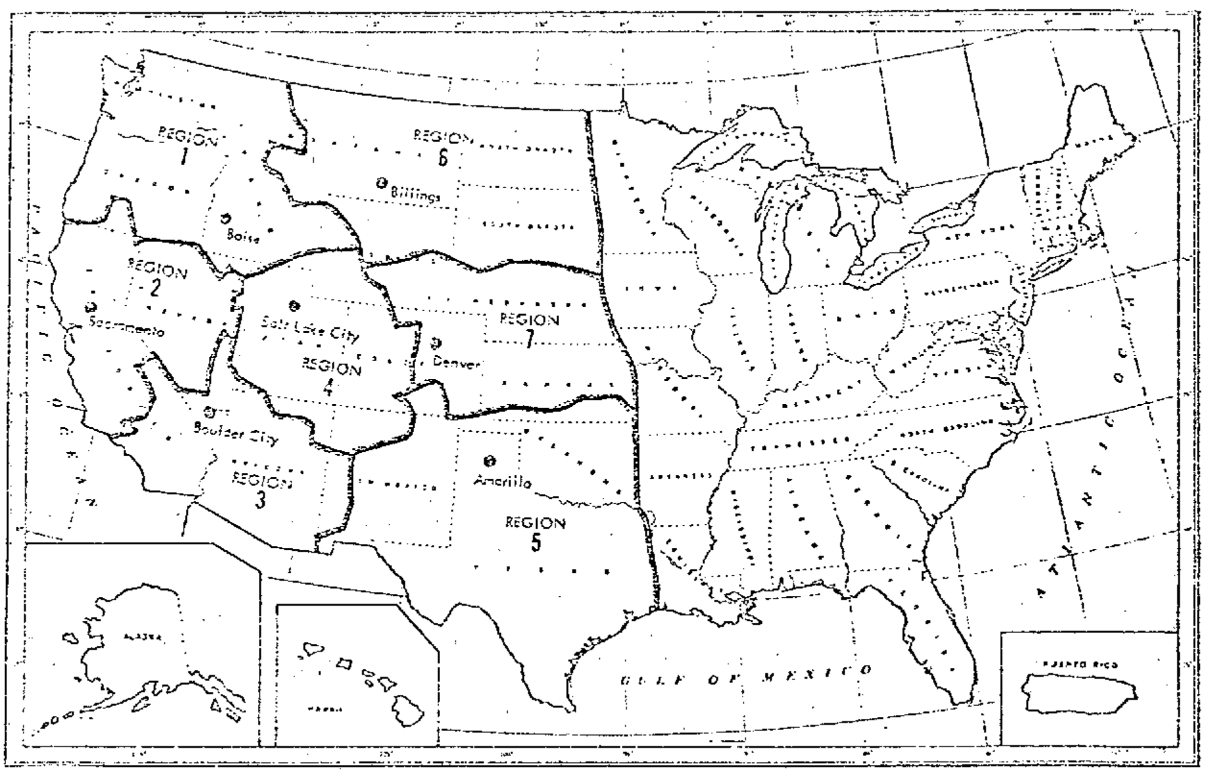
Department of the Interior

Bureau of Reclamation

A. Activities

1. Water supply and distribution investigations
2. Water resource project planning & management
3. Sedimentation
4. Cloud seeding/Weather modification
5. Irrigation

B. Locations of Bureau of Reclamation Region and Office



Source: <u>The Water Encyclopedia</u>, Water Resources Council, p. 499

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Research Category	Allocation of Funding by Fiscal Years (thousands of dollars)		
	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
Atmospheric Water Resources Management	6,574	6,559	6,388
Regional Research	220	479	444
Water Resources Planning and Engineering Research	2,434	2,884	2,468
TOTAL	9,228	9,922	9,300

Distribution of Funding
(thousands of dollars)

	FY 1971	FY 1972	FY 1973
In house	3,549	4,218	4,181
Industry	1,303	943	1,006
University	3,818	4,124	3,518
Other	558	637	595

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 45

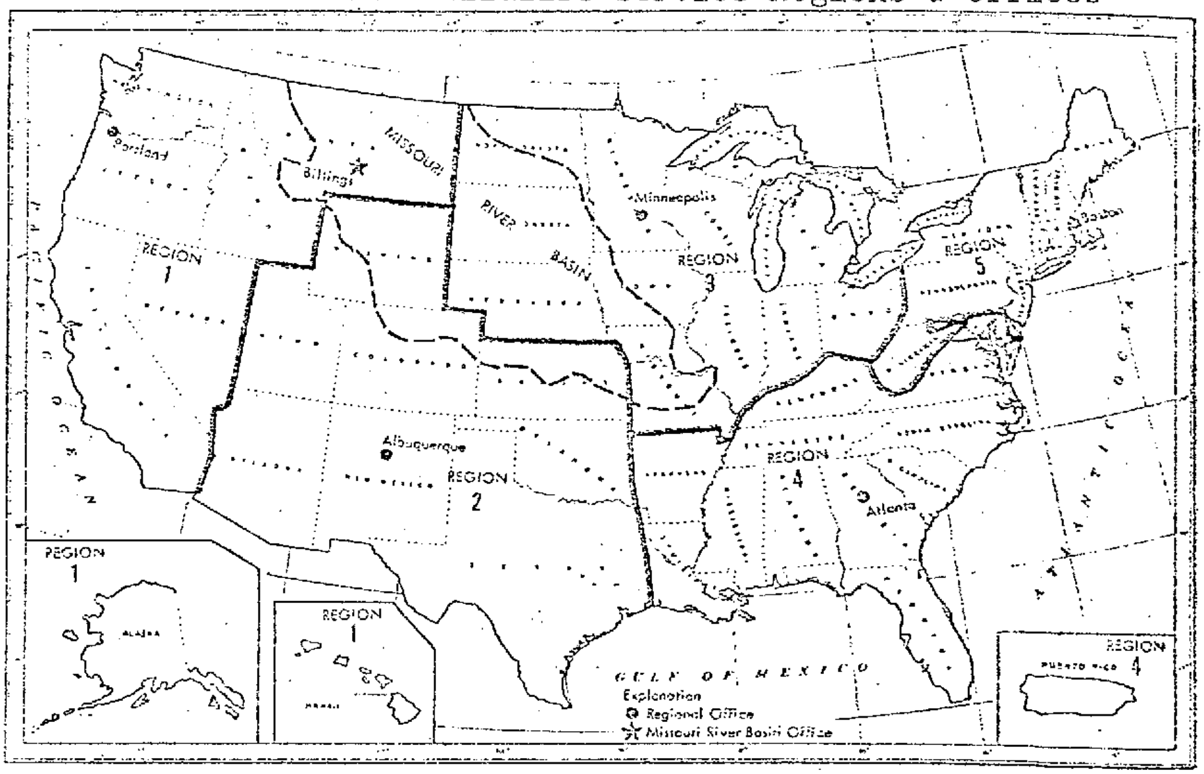
Department of the Interior

Fish and Wildlife Service

A. Activities

1. Fresh water inventory
2. Wetland inventory
3. Sea ice breakup studies
4. Remote sensing to assist impact of water development projects on fish and wildlife resources
5. Coastal marsh inundation
6. Surface area in small impoundments as related to production of fishes
7. Thermal pollution investigation

B. Locations of Fish & Wildlife Service Regions & Offices



Source: The Water Encyclopedia, Water Resources Council

DEPARTMENT OF THE INTERIOR

Fish & Wildlife Service

Allocation of Funding by Fiscal Years
(thousands of dollars)

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
Thermal Pollution	108	224	535
Water Quality	2,416	2,638	2,460
Conserving Ecological Values in Water Resource Planning	1,187	1,226	1,172
Other	937	1,011	850
TOTAL	4,648	5,099	5,017

Distribution of Funding
(thousands of dollars)

	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
In-house	3,071	3,492	3,125
University	50	50	381
	1,527	1,557	1,511
TOTAL	4,648	5,099	5,017

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 49

Department of the Interior

Bonneville Power Administration

A. Activities

1. Marketing of surplus electric power
2. Operation and maintenance of transmission facilities
3. Power requirements studies
4. Planning and integration of power resources

B. Budget FY 1973

Construction	$ 94,493,000
Operation & Maintenance	31,020,000
Administration	102,000
Trust Fund Receipts	20,623,000
Total	$146,238,000

Source: Budget of the U.S. Government, FY 1975

Environmental Protection Agency

A. Activities

1. Identify and quantity pollutants
2. Develop technology for pollution control
3. Develop methods for pollution detection
4. Pollution stress modeling
5. Urban, industrial and agricultural pollution control
6. Environmental impact studies

ENVIRONMENTAL PROTECTION AGENCY

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
V. Water Quality Management and Protection			
A. Identification of pollutants	3,959	2,948	3,212
B. Sources and fate of pollution	3,405	4,301	8,157
C. Effects of pollution	9,279	9,337	11,386
D. Waste treatment process	40,551	24,253	22,641
E. Ultimate disposal of wastes			
F. Water treatment and distribution	-	888	704
G. Water quality control	1,326	610	880
SUBTOTAL	58,520	42,337	46,980
VI. Water Resources Planning			
A. Techniques of planning	176	242	131
B. Evaluation process	125	186	182
C. Cost allocation, cost sharing, pricing, repayment	-	-	101
D. Water demand	-	-	61
E. Water law and institutions	150	223	344
F. Non-structural alternatives	50	93	71
G. Ecological impact of water development	-	-	121
SUBTOTAL	501	744	1,011
VII. Resources Data			
A. Network design	77	31	33
B. Data acquisition	270	102	108
C. Evaluation, processing and publication	135	53	56
SUBTOTAL	482	186	197
TOTAL	59,503	43,267	48,188
Extramural (included in above amounts)			
Contracts and co-op agreements	14,746	12,534	9,687
Grants	26,796	13,057	15,957

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 89

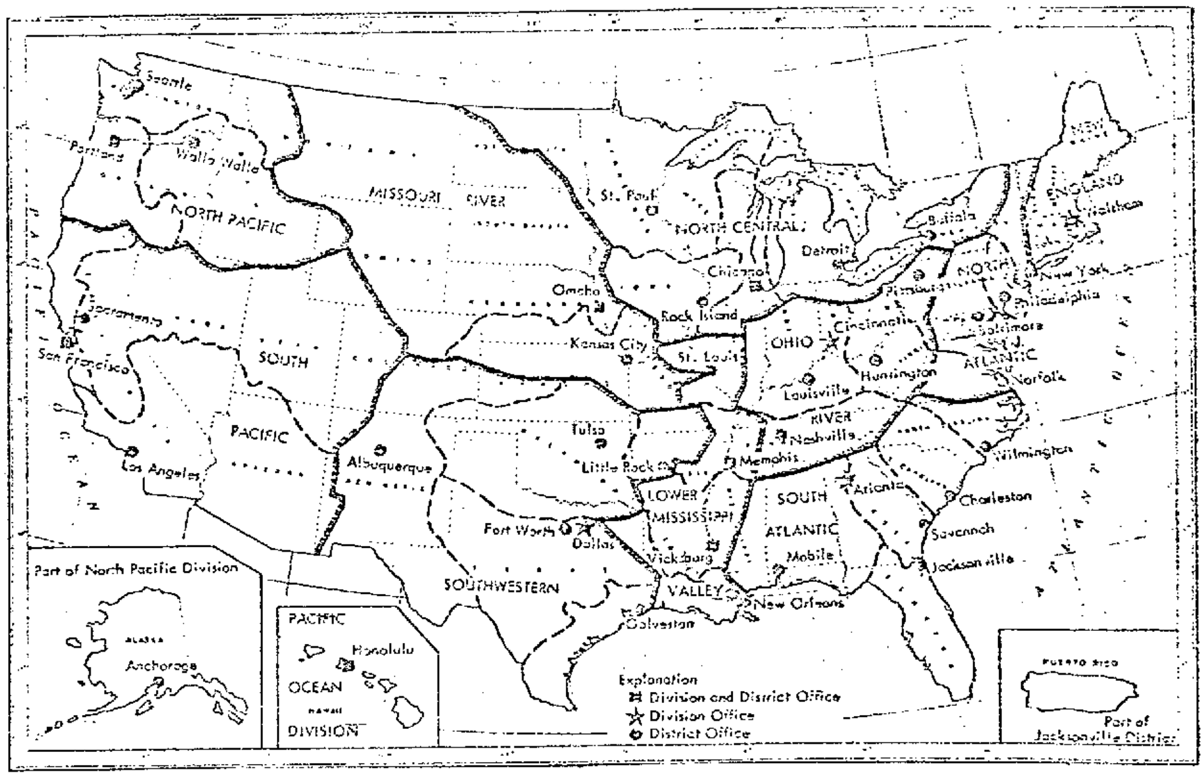
Department of Defense

U.S. Army Corps of Engineers

A. Activities

1. Comprehensive river basin and regional planning
2. Reservoir sizing
3. Reservoir management
4. Flood plain mapping
5. Flood control projects
6. River hydraulic models
7. Research in coastal zone hydrology - coastal engineering activities
8. River basin studies
9. Flood frequency studies
10. Rainfall - runoff investigations

B. Locations of Corps of Engineers Regions & Offices



Sources: The Water Encyclopedia, Water Resources Council, p. 484

DEPARTMENT OF DEFENSE (CIVIL)

Army Corps of Engineers

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
II. Water Cycle			
A. General	213	235	230
B. Precipitation	131	145	143
C. Snow, ice, and frost	24	-	-
H. Lakes	224	-	-
J. Erosion and sedimentation	883	759	727
L. Estuaries	277	571	626
SUBTOTAL	1,752	1,710	1,726
IV. Water Quantity Management and Control			
A. Control of water on the surface	500	500	500
V. Water Quality Management and Protection			
G. Water quality control	100	450	720
VI. Water Resources Planning			
A. Techniques of planning	545	595	495
B. Evaluation process	780	1,400	1,365
G. Ecologic impact of water development	434	765	932
SUBTOTAL	1,759	2,760	2,792
VII. Resources Data			
B. Data acquisition	5	5	10
VIII. Engineering Works:			
A. Structures	311	497	518
B. Hydraulics	3,042	3,466	2,189
C. Hydraulics machinery	150	500	846
D. Soil mechanics	552	642	529
E. Rock mechanics and geology	225	299	396
F. Concrete	509	561	470
G. Materials	45	125	60
H. Rapid excavation	960	61	200
I. Fisheries engineering	125	145	155
SUBTOTAL	5,919	6,296	5,363

DEPARTMENT OF DEFENSE (CIVIL)

Army Corps of Engineers

Research Category (cont.)	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
X. Scientific and Technical Information:			
D. Specialized information center services	28	100	67
TOTAL	10,063	11,821	11,178

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R. p. 36-37.

TENNESSEE VALLEY AUTHORITY

I. Activities

A. Rainfall studies

B. Evaporation

C. Modeling

1. Water yield, storm hydrograph, water quality

2. Effect of land-use changes

D. Development of water resource management methods

E. Flow frequency studies

F. Effects of urbanization upon streamflow

G. Measurement of sediment & sediment density

H. Forest hydrology

I. Irrigation

J. Ecologic studies

K. Water quality

L. Thermal pollution

M. River & reservoir water-control structures

N. Nutrient enrichment

O. Radiological impact of an expanding nuclear-power economy (HERMES model)

P. Wastewater irrigation

TENNESSEE VALLEY AUTHORITY

Research Category	FY 1971 (actual)	FY 1972 (actual)	FY 1973 (estimate)
	Allocation of Funding by Fiscal Years (thousands of dollars)		
II. Water Cycle			
A. General	148	128	99
B. Precipitation	80	72	78
D. Evaporation and transpiration	7	8	8
E. Streamflow and runoff	102	57	66
F. Groundwater			
H. Lakes	2	2	2
J. Erosion and sedimentation	12	5	5
SUBTOTAL	351	272	258
IV. Water Quantity Management & Control			
A. Control of water on the surface	94	76	85
C. Effects of man's non-water activities	51	91	84
SUBTOTAL	145	167	169
V. Water Quality Management & Protection			
B. Sources and fate of pollution	337	318	232
G. Water quality control	256	281	263
SUBTOTAL	593	599	495
VI. Water Resources Planning			
A. Techniques of planning	3	150	277
B. Evaluation process	17	16	5
G. Ecologic impact of water development	--	--	12
SUBTOTAL	20	166	294
IX. Manpower, Grants and Facilities			
B. Education--in-house	3	3	3
D. Grants, contracts & research allotments	3	1	5
SUBTOTAL	6	4	8
TOTAL	1,115	1,208	1,224

Source: Federal Water Resources Research Program for 1972, William S. Butcher, O.W.R.R., p. 114

APPENDIX K

HYDROLOGIC MODELS USED BY FEDERAL AGENCIES

Appendix K lists hydrologic models used by the federal water resource agencies. Applications and origins of the models are also included.

HYDROLOGIC MODELS USED BY FEDERAL AGENCIES

DEPT.	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
USDA	Agricultural Research Service	HL-70	Agri.-Chem Transport Water Balance Erosion Reservoir Sedimentation	X	
		Wischmier's Universal Soil Loss Equation	Agri.-Chem Transport Water Balance Erosion Reservoir Sedimentation		
		Precipitation Models	Precipitation	X	
		Snowmelt Models	Snowmelt	X	
	Soil Conservation Service	Snowmelt and Yield	Snowmelt		
		Storm Runoff	Rainfall-R/O Computation & Modeling		
		Stream Routing with Hydrographs			
		Urban Hydrology			
		Radiation as a measure of water content of snow			
		TR-20		X	
	Forest Service	BURP	Water Yield		
		EROSON	Erosion		
		Snowmelt	Snowmelt		
		INVEST III	Economic Ana.		
		Resources Planning	Resource Planning		

HYDROLOGIC MODELS USED BY FEDERAL AGENCIES

DEPT.	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
US Army	Corps of Engineers North Pacific Div.	Lammit			River Forecast Center, ORE.
		SSARR	Streamflow Simulation & Reservoir Regulation		
		HYSIS	Hydro-systems Simulation		
	Corps of Engineers Hydrologic Engineering Center	HEC I	Simulation-traditional large scale	X	
		HEC II	River Hydraulics	X	
		HEC III	Reservoir Systems, Conserv.	X	
		HEC IV	Statistical Streamflow	X	
		HEC V	Large Scale Systems of Flood Reservoirs	X	
Commerce	NOAA	API			
		SSARR			Corps of Engineers
		Stanford			Stanford University
		Sacramento			Sacramento River Cent[illegible]
DOI	Geologic Survey	Modeling of Estuaries and Groundwater	Groundwater Estuaries		
	Bureau of Reclamation	Weather Modification		X	
		Reservoir Operation Studies	Res.-Water Supply Man.	X	

HYDROLOGIC MODELS USED BY FEDERAL AGENCIES

DEPT.	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
		Reservoir & Aquaduct Sizing	Res.-Water Supply Man.	X	
		Salinity Modeling	Water Quality	X	
		Flow Predictions for Operational Projects		X	
Bonneville Power Admin.		SSARR COSSARR	Streamflow Simulation & Reservoir Regulation		COE
		Many Reservoir Ops. Programs			
Environmental Protection Agency		Large number of specific purpose water quality models	Water Quality	X	
Tennessee Valley Authority		Urban Flood	Economic Ana.	X	
		HUD - Flood Insurance	Economic Ana.	X	
		Phytoplankton Program	Water Quality	X	
		Carbon 14 & Chlorophyll Productivity Analysis	Water Quality	X	
		New Backwater	Flood Fore.	X	
		Flood Assembly & Prediction	Flood Fore.	X	
		Natural & Regulated Flood Estimation	Flood Fore.	X	
		Flood Hydrograph	Flood Fore. River Hydrau.	X	
		Flow Frequency	Res.-Water Supply Man.	X	
		Tenn. Flow Volumes	River Hydrau.	X	

HYDROLOGIC MODELS USED BY FEDERAL AGENCIES

STATE	AGENCY	MODEL NAME	APPLICATION	ORIGIN OF MODEL	
				IN HOUSE	OTHER
TVA - Cont.		Modified Reservoir Routing	Res.-Water Supply Man.	X	
		Simulation of Open Channel Hydraulics	River Hydrau.	X	
		Simulation of Open Channel Hydraulics Junction	River Hydrau.	X	

APPENDIX L

COMPUTERS IN WATER RESOURCE USE BY FEDERAL AGENCIES

Appendix L lists the computers used by each federal water resource agency, indicating utilization (whether shared or dedicated), location if not in-house, total use in hours per week, and percentage of total utilization for water resource activities.

STATE	AGENCY	COMPUTER	UTILIZATION SHARED	UTILIZATION DEDICATED	LOCATION IN HOUSE	LOCATION ORGANIZATION & CITY	TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
USDA	Agricultural Research Service	CDC 7400	X			Tucson		
		IBM 360/75	X			Idaho Nuclear		
		IBM 360/65 1130	X			New Orleans		
		CDC 6600	X			Tucson		
		Sigma 7 IBM 360/40	X			Vermont		
		IBM 370/168	X			Ohio, Washington, D.C.		
		UNIVAC 1108	X			Fort Collins		
	Soil Conservation Service	IBM 360/75	X			Ft. Worth, New Orleans 168		
		IBM 370/168	X			Washington, D.C.		$2-3000 mo. on CPU time
		UNIVAC 1108	X			Fort Collins		
		2 IBM 360/50	X			Kansas City		
	Forest Service	Outside contractors						

STATE	AGENCY	COMPUTER	UTILIZATION SHARED	UTILIZATION DEDICATED	LOCATION IN HOUSE	LOCATION ORGANIZATION & CITY	TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
		UNIVAC 1108	X		X	Fort Collins	2 shifts/ day	Unknown
		CDC 3100's	X		X			Some
Army	COE No. Pac. Div.	GE 225-437 (11) system	X		X			
		IBM 360/50	X		X		168	30
		IBM 1800	X		X			
		GE 4020	X		X			
		CDC 1700	X		X			
	COE Lower Miss. Valley Div.	2 Honeywell GE 635	X		X			
		GE 437/225 system	X		X			
		CDC 7600	X			Berkeley	≈80	
	COE Hydrologic Engr. Center	UNIVAC 1108			X		≈25%	
		a few CDC 6600's CDC 7600 Corps GE in Vicksburg			X		≈75%	

COMPUTERS IN WATER RESOURCE USE BY FEDERAL AGENCIES [redacted]

STATE	AGENCY	COMPUTER	UTILIZATION: SHARED	UTILIZATION: DEDICATED	LOCATION: IN HOUSE	LOCATION: ORGANIZATION & CITY	TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
	COE Norfolk, Va. Dis.	Honeywell G-437 Digital			X			10 hrs/mo
DOI	Geologic Survey	IBM 360/91				Watson Research Center, IBM, N.Y.		
		IBM 370/155				Reston, Va.	2 shifts/ day	58%
		IBM 360/91				John Hopkins Applied Physics Lab		
		IBM 360/65			X	Washington, D.C.		
		CDC 7600 & others						
	Bureau of Reclamation	CDC Cyber 70/74	X			Engineering & Research Center, Denver	20 hrs/day	n/a
	Bureau of Sport Fisheries & Wildlife	Developing computer capability						
Commerce	NOAA	IBM 1130 (11)			X	River Forecast Centers		
		IBM 1620				Silver Spring		

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs./wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
	E.P.A.	IBM 1130			X	Charlottesville		
		IBM 1130			X	Durham		
		IBM 360/50			X	Durham		
		IBM 1130			X	Dallas		
		IBM 1130			X	Ada		
		IBM 360/30			X	Cincinnati		
		IBM 1130			X	Cincinnati		
		IBM 1130			X	K.C.		
		IBM 1130			X	San Francisco		
	Fish and Wildlife Service	IBM 360/20			X	Laurel, Md.		
		IBM 1130			X	Ann Arbor		
		PDP 12			X	Columbia, Mo.		

STATE	AGENCY	COMPUTER	UTILIZATION		LOCATION		TOTAL USE (Hrs/wk)	% of total utilization for water res. activities
			SHARED	DEDICATED	IN HOUSE	ORGANIZATION & CITY		
	B.P.A.	CDC 1700			X	Portland, Ore.		
		CDC 6400			X	Portland, Ore.		
		IBM 1401			X	Portland, Ore.		
	T.V.A.	IBM 370/165			X	Chattanooga, Tenn.		
		IBM 360/30			X	Knoxville, Tenn.		
		IBM 360/50			X	Knoxville, Tenn.		